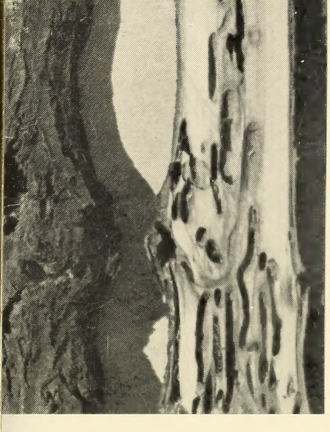
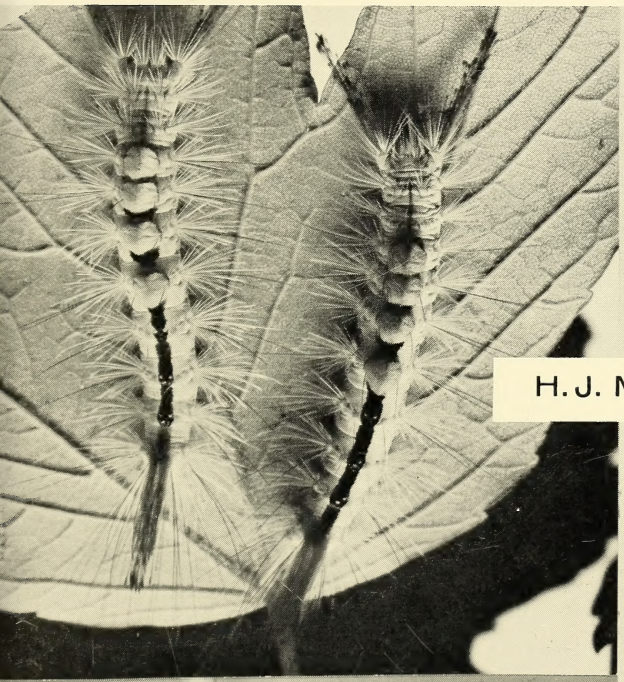
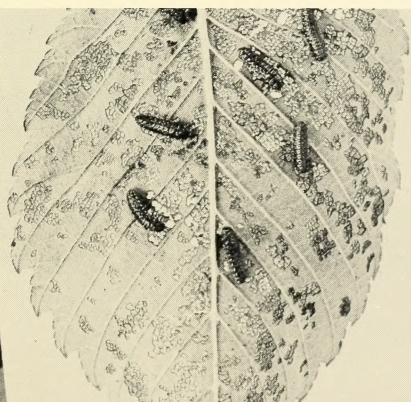
U.S. FOREST SERVICE
RESEARCH PAPER LS-11
JULY 1964

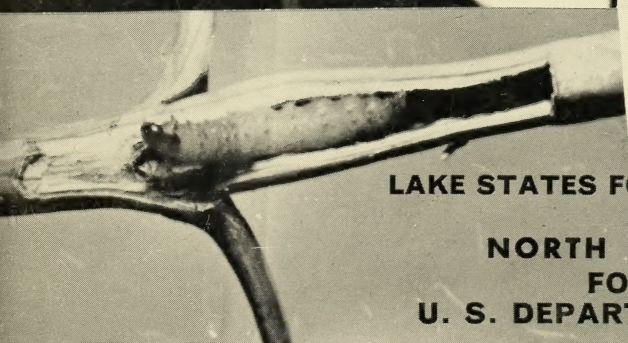


Identification of Hardwood Insects by Type of Tree Injury, North-Central Region



H.J. MacAloney and H.G. Ewan





LAKE STATES FOREST EXPERIMENT STATION
and
NORTH CENTRAL REGION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

FOREWORD

In the U.S. Forest Service, responsibilities for the forest insect surveys and research are assigned respectively to the North Central Regional Office and the Lake States Forest Experiment Station. The Region conducts detection and evaluation surveys of insect infestations, initiates control measures on National Forests, and provides technical assistance on control programs to private, State, and other Federal land-managing groups when appraisals indicate that control measures are justified. The Station conducts research on the biology, ecology, and control of insects. Results of the research are published periodically and are summarized in the Station's annual report.

Prompt and correct identification and reporting of forest insects can do much to indicate the location of infested areas where control measures are needed. This publication, prepared by the Station and financed by the Region, is a companion paper to Station Paper 100, "Identification of Conifer Insects by Type of Tree Injury, Lake States," by H. J. MacAloney and D. C. Schmiege. Recognizing the need for information to enable field identification of injury by hardwood insects, Dr. MacAloney undertook the preparation of this paper following his retirement from active duty in November 1961. In the preliminary stages, Dr. H. G. Ewan, recently deceased, contributed greatly from his knowledge and experience in the Region.

As an aid to identification a large number of photographs have been included. Many of them were obtained from agencies outside the Forest Service. Permission to use them is gratefully acknowledged.

CONTENTS

(Continued)

Cover: Examples of hardwood insects or their damage to trees. Top left — locust borer; top right — woolly elm aphid; center left — white-marked tussock moth; center right — basswood leaf miner; bottom left — boxelder twig borer; bottom right — elm leaf beetle.

MacAloney, H. J., and Ewan, H. G.

1964. Identification of hardwood insects by type of tree injury, North-Central Region. Lake States Forest Expt. Sta., St. Paul, Minn. 70 pp., illus. (U.S. Forest Serv. Res. Paper LS-11)

Contains a key; a table giving clues to the identification of free-feeding defoliators; brief discussions of the hosts, tree damage, and description of many important hardwood insects; and 82 illustrations. The report is designed to help the fieldman without specialized training in entomology to identify insects causing tree damage. Some brief notes on life history and habits are included, but control methods are not discussed.

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the State Entomology Department. Prevention of population build-up through silvicultural practices designed to bring about forest conditions unfavorable to the development of outbreaks should be an integral part of timber management plans.

A brief bibliography is included at the end of the report for the reader who may want additional information on the insects discussed here.

KEY AND TABLE

Obviously a key for identifying insects by type of tree injury does not follow normal taxonomic patterns; type of damage is not related to insect order, family, or even genus. Thus the damage key presented here "crosses" all taxonomic classifications. It is not intended to be all-comprehensive, but rather to supply a means for field identication. Since there are literally thousands of species that live on hardwoods, the key, with about 100 species, is far from complete. An attempt has been made, however, to include those species which have in the past caused damage or which have noticeable feeding habits. Some insect vectors of diseases affecting forest trees in the north-central region are mentioned in the general discussion but are not included in the key.

Since tree damage is usually clearcut, most individual species can be identified with a reasonable degree of confidence by using this key. But some species do not lend themselves to separation by types of injury because they damage trees in much the same way. For example, the injury caused by the free-feeding defoliators is destruction of the foliage by chewing. Usually this destruction is not sufficiently characteristic to separate the many individual species that cause it. For these insects, therefore, a table was developed to separate the individual insects by period when defoliation is most noticeable, favored hosts, and feeding habits and feeding stages. This table is presented on the pages following the key.

Most of the species are found throughout the region in greater or less abundance. Some species are of more importance in one specific area, such as the green-striped mapleworm in the northern forest or the leaf beetles in the shelterbelts.

For the benefit of those not accustomed to using a key such as shown here, an example follows:

Assume that slight swellings are noticeable on the current season's twigs of quaking aspen. Item 1 in the key shows all damage is divided into two groups: (1) Foliage eaten or otherwise damaged and (2) other tree parts damaged. In our example the twigs are damaged, which leads us to item 4 in the key.

Two choices are given in item 4: Twigs, branches or small stems with (1) typical galls or swellings, or (2) with various scales, slits, tunnels, holes, scars, varnish (discolored sap on bark), or swellings which are not typical galls. The damage consists of small swellings that are not typical galls so we refer to item 25.

Here again we have two choices: (1) Injury to buds, twigs, and small branches and (2) injury to larger branches and stems. The damage occurs in the twigs and, therefore

item 26 is selected. Since the host is *not* maple we take the second choice which leads to item 27.

Inspection of the two choices in item 27 eliminates the first since there is no evidence of scales on the bark. Selection, therefore, is the second choice covering injury due to tunneling in the current season's twigs; this refers us to item 37. The insects concerned are called twig borers. The key further states that if aspen is the tree species attacked, our insect is the poplar twig borer. A reference to the Table of Contents shows that description of the damage and of the insect itself can be found on page 55.

It must be emphasized that positive identification, especially for the defoliators, may require detailed examination by a trained entomologist and recourse to definitive taxonomic keys. Whenever possible, particularly if the collector is in doubt concerning the identity of an insect, specimens should be sent to the State Entomologist for determination and for suggestions on control.

A few terms that may not be familiar to all readers are defined:

Larva. — The immature stage between the egg and the pupa of an insect having complete metamorphosis (complete when a pupa is present).

Instar. — The period or stage between larval molts.

Pupa. — The stage between the larva and the adult; a period of marked developmental changes.

Crawler. — A newly hatched scale insect.

Nymph. — An immature, wingless form, sometimes closely resembling the adult, such as the walkingstick.

Caterpillar. — The larva of a moth or butterfly.

Leaf miner. — A larva that lives in and feeds on the tissues between the upper and lower leaf surfaces.

Leaf skeletonizer. — A larva that feeds on the external tissues of the leaf surface.

Leaf roller, leaf tier. — A larva that feeds on the tissues of a leaf rolled or tied with silken strands.

Leaf curl. — Distortion of a leaf due to the feeding activity of a sucking insect.

Free-feeding defoliators. — Those insects that feed on the foliage without the protection of tents, webs, mines, rolled leaves, etc.

Solitary. — Feeding habitually alone, not in groups or colonies.

Gregarious. — Feeding in groups or colonies.

Frass. — Refuse, either excrement or sawdust or a mixture, expelled by feeding insects.

Thorax. — The body division behind the head, which bears the wings and the true legs.

Wing covers. — Hard coverings (elytra) on beetles to protect the membranous true wings.

Dorsal. — Pertaining to the upper surface or back of an insect.

Ventral. — Pertaining to the under surface or the abdomen of an insect.

Key Based on Type of Tree Injury

1. Foliage eaten or otherwise damaged 2
1. Other tree parts damaged; sometimes wilting and death of foliage occurs 4

2. Foliage eaten — entire leaves or parts of leaves (does not include mining, skeletonization, webbing, tenting, leaf rolling, galls, discolored spots, fleck, or punctures, etc.) .....See table 1 — FREE-FEEDING DEFOLIATORS
2. Foliage damaged — mining, skeletonization, webbing, tenting, leaf rolling, galls, discolored spots, flecks, or punctures, etc. 3

3. Partial to complete injury of leaf tissues associated with mining, skeletonization, webbing, tenting, leaf rolling, etc. 11
3. Partial injury of leaf tissues by galls, discolored spots, flecks, punctures, etc. 15

4. Twigs, branches, or small stems with typical galls or swellings 5
4. Twigs, branches, or stems with various scales, slits, tunnels, holes, scars, varnish (discolored sap on bark), swellings (not typical galls) 25

5. Galls on twigs and small branches of oaks 6
5. Galls on twigs, branches, or small stems of other hardwoods 9

6. Galls apparently developing as single swellings 7
6. Galls developing individually but in well-defined masses 8

7. Twigs with much-enlarged, rough, woody swellings composed of numerous galls fused together .....GOUTY OAK GALL
7. Twigs with much-enlarged swellings with hollow, conelike horns .....HORNED OAK GALL

8. Conical, strongly ribbed galls, about ⅛ inch in diameter, in masses along cracks in the bark .....RIBBED OAK GALL
8. Bladderlike growths, ¼ to ½ inch in diameter, in dense clusters around twigs .....OAK FIG GALL

9. Galls on twigs and branches of red maple .....GALL-MAKING MAPLE BORER
9. Galls on twigs or stems of root suckers or seedling stock of aspen 10

10. Swelling usually smooth on living twigs or on the upper parts of stems; egg pockets in single, horseshoe-shaped incisions in bark .....Two species, POPLAR-GALL SAPERDAS
10. Swellings usually knotty at base of stems with broken places in bark through which frass is pushed; groups of eggs in slits in bark .....POPLAR-AND-WILLOW BORER

11. Several leaves or branches with tent or webbing 12
11. Leaves mined, skeletonized, rolled, or tied together 14

12. Tents formed in branch forks ..EASTERN TENT CATERPILLAR
12. Webs on branches, enclosing foliage 13

13. Aspen — only a few leaves webbed together at branch tips .....PRAIRIE TENT CATERPILLAR

13. Various hosts — few to many leaves webbed together:
Several hosts — webs present July to October ..FALL WEBWORM
Oaks — webs present spring to early summer ....OAK WEBWORM
Cherry — webs present spring to early summer .....UGLY-NEST CATERPILLAR
Maple — webs present in midsummer .....MAPLE WEBWORM

14. Leaves individually rolled or tied with silk:
Numerous hosts — feeding damage in May and early June .....FRUIT-TREE LEAF ROLLER
Aspen:
Leaves rolled in spring .....ASPEN LEAF ROLLER
Leaves rolled in July .....LARGE ASPEN TORTRIX
Basswood — leaves rolled in late summer .....BASSWOOD LEAF ROLLER
Maples — leaves rolled in May and June .....Two species, MAPLE LEAF ROLLERS

14. Leaves mined or skeletonized:
Aspen:
Blotchy mines in late June and early July and again in August .....ASPEN BLOTCH MINER
Labyrinthine mines in July .....ASPEN LEAF MINER
Skeletonization of lower surface by beetle larvae in early summer .....COTTONWOOD LEAF BEETLE
Mines in upper leaf tissues by beetle larvae in June .....COTTONWOOD LEAF-MINING BEETLE
Birch:
Leaves mined by early stage moth larvae in early July; later stages skeletonize lower leaf tissues; one generation per year .....BIRCH SKELETONIZER
Blotchy mines by sawfly larvae in June and again in midsummer; two or more generations per year .....BIRCH LEAF MINER
Oak:
Leaves skeletonized by moth larvae early in July and again in late August and September ..OAK SKELETONIZER
Solitary mines in each leaf by moth larvae in July .....SOLITARY OAK LEAF MINER
Gregarious mines, several moth larvae in each mine, in July .....GREGARIOUS OAK LEAF MINER
Basswood:
Leaves skeletonized by beetles in late June and July; mined by larvae in late July and August .....BASSWOOD LEAF MINER
Elm:
Leaves skeletonized by larvae in early summer .....ELM LEAF BEETLE
Leaves mined by sawfly larvae in late May and early June .....ELM LEAF MINER

14. (Cont'd.)

Black locust:
Lower leaf surface skeletonized by beetles in spring; mining by larvae during the summer ..... LOCUST LEAF MINER

15. Leaves with galls 16
15. Leaves with discolored spots or flecks, edges of leaves sometimes twisted or curled 24

16. Galls on foliage of oak 17
16. Galls on foliage of other species 19
17. Large, globular galls, usually single, green or brown, up to 2 inches in diameter; on several species in the red oak group ..... LARGE OAK-APPLE GALL
17. Small galls, usually numerous, up to ½ inch in diameter 18

18. Hemispherical galls, about ⅛ inch in diameter, covered with white hairs; many galls on leaf undersurface causing curling. Swamp white oak a favored host ..... OAK FLAKE GALL
18. Reddish bladderlike galls in dense clusters, ¼ to ½ inch in diameter along central vein of leaf undersurface. Mostly on white oaks ..... OAK FIG GALL

19. Small galls about ⅛ inch in diameter and bladderlike or nipplelike in form on maple or hackberry leaves 20
19. Galls up to 2 inches in diameter on ash or aspen leaves 21

20. Galls on maple leaves, bladderlike in form and mostly on the upper surface; color light green at first, then changing to reddish and black ..... MAPLE BLADDER-GALL MITE
20. Galls on hackberry leaves; nipplelike in form on the lower surface with depression on upper surface; color light green ..... HACKBERRY NIPPLE GALL

21. Distorted galls on ash leaves, formed in the male flowers and ranging from ½ to 2 inches in diameter .. ASH FLOWER-GALL MITE
21. Galls on aspen leaves 22

22. Twisted or coiled galls, up to 2 inches in diameter, involving leaves at tips of twigs; green at first, dark brown to black when mature ..... POPLAR VAGABOND APHID
22. Globular or semiglobular galls, usually at junction of petiole and leaf proper but sometimes midway on petiole.... 23

23. Globular galls at junction of petiole and leaf proper, up to ⅜ inch in diameter ..... ASPEN PETIOLE GALL MOTH
23. Semiglobular galls, usually at junction of petiole and leaf proper but sometimes midway on petiole, ½ inch or more in diameter ..... Three species, POPLAR PETIOLE GALL APHIDS

24. Leaves with discolored spots or flecks .. Two species, LACE BUGS
24. Leaves with edges sometimes twisted or curled, but not rolled ..... Three species, WOOLLY APHIDS

25. Injury to buds, twigs, and small branches 26
25. Injury to larger branches and stems 38

26. Buds and leaf stalks on sugar maple mined and killed, usually causing forked growth .....MAPLE BUD BORERS
26. Twigs and small branches of other hardwoods injured by scale or boring insects 27

27. Bark of new and old growth infested with scales of varying sizes and colors 28
27. Pith or center of twigs of current season tunneled 37

28. Scales with marginal cottony or waxy secretion 29
28. Scales without marginal secretion 32

29. Scales with cottony masses, looking like partially popped popcorn 30
29. Scales with waxy secretion 31

30. Scales dark purple, 3/10 inch long .....MAPLE LEAF SCALE
30. Scales brown, ¼ inch long .....COTTONY MAPLE SCALE

31. Scales oval, reddish brown with white, waxy, marginal filaments .....EUROPEAN ELM SCALE
31. Scales pear-shaped, usually dirty-white with grayish secretion .....ELM SCURFY SCALE

32. Scales oystershell-shaped, light to dark brown in color .....OYSTERSHELL SCALE
32. Scales circular, variously colored, or pitted 33

33. Scales greenish gold in color; small gall-like pits in bark .....GOLDEN OAK SCALE
33. Scales reddish brown or gray in general color 34

34. Scales reddish brown 35
34. Scales grayish 36

35. Scales with a black band or mottling and without powdery covering .....TERRAPIN SCALE
35. Scales without bands but often with a powdery covering .....EUROPEAN FRUIT LECANIUM

36. Scales light gray with a depressed yellow ring in center .....SAN JOSE SCALE
36. Scales dark gray with a reddish center .....PUTNAM SCALE

37. Tunnels in center of current season's twigs, causing slight swellings; injury chiefly to nursery stock and small saplings .....TWIG BORERS
Boxelder .....BOXELDER TWIG BORER
Black locust .....LOCUST TWIG BORER
Aspen .....POPLAR TWIG BORER
37. Twigs pruned or girdled; injury chiefly to branches up to 2 inches:
Oak .....TWIG PRUNER
Birch, beech, and maple .....BIRCH AND BEECH GIRDLER

38. Galleries in inner bark or on surface of wood 39
38. Galleries in wood itself 41

39. Characteristic bark beetle tunnels — egg galleries forked and across grain of wood, larval tunnels lengthwise .....ASH BARK BEETLES
39. Tunnels superficial; serpentine or meandering 40

40. Serpentine galleries extending lengthwise of the bole, old attacks appearing in cross section as shallow, stained galleries ..... CAMBIUM MINER

40. Meandering galleries on surface of wood and in outer layers of sapwood, with hibernating chambers often a half-inch deep; wood not stained:
    Oak, beech, eastern hophornbeam ..... TWO-LINED CHESTNUT BORER
    Birch ..... BRONZE BIRCH BORER
    Aspen ..... BRONZE POPLAR BORER

41. Injury mainly in base of trees 42

41. Injury mainly in upper part of trunk or in larger branches 45

42. Galleries in heartwood of old or low-vigor trees, usually in decayed areas or in tunnels made by other insects ..... BLACK CARPENTER ANT

42. Galleries in sound wood of living trees; cast pupal shells protruding from emergence holes 43

43. Individual galleries and emergence holes large, about ½ inch in diameter; larvae 2 to 3 inches long ..... CARPENTERWORM

43. Individual galleries and emergence holes small, about ⅛ inch or less in diameter: larvae ½ to ¾ inch long 44

44. Ashes attacked — young trees preferred; full-grown caterpillars about ¾ inch long ..... ASH BORER

44. Maples attacked — larger trees preferred; full-grown caterpillars about ½ inch long ..... MAPLE CALLUS BORER

45. Chief evidence of attack — egg slits cut into inner bark, boring dust, sap leakage, larval galleries in sapwood or heartwood irregularly winding, emergence holes ¼ to ½ inch in diameter:
    Sugar maple ..... SUGAR-MAPLE BORER
    Quaking aspen ..... POPLAR BORER
    Cottonwood ..... COTTONWOOD BORER
    Black locust ..... LOCUST BORER
    Red oak ..... RED-OAK BORER
    White oak ..... WHITE-OAK BORER
    Elm ..... ELM BORER
    Ash ..... BANDED ASH BORER or RED-HEADED ASH BORER

45. Chief evidence of attack or emergence — small cylindrical pinholes up to ⅛ inch in diameter; larval galleries deep in wood 46

46. Pinholes about ⅛ inch in diameter; galleries usually in recently felled or in dying trees; larval tunnels usually single and running in all directions; wood not stained ..... OAK TIMBERWORM

46. Pinholes about 1/16 inch in diameter; larval galleries stained dark brown or black by ambrosial fungus 47

47. White oaks; sapwood of living trees preferred ..... COLUMBIAN TIMBER BEETLE

47. Birch, oak, maple, elm; sapwood and heartwood of dying or recently cut trees preferred ..Three species, AMBROSIA BEETLES

Table 1 — Free-Feeding Defoliators — Clues Leading to Their Identification

Period defoliation is most noticeable	Favored hosts	Description of feeding habits and feeding stages	Insect species
MOTHS AND BUTTERFLIES (LEPIDOPTERA)			
Mid-May to mid-June	Aspen, sugar maple	Gregarious; a silken mat, not a tent. Pale bluish caterpillar with a row of keyhole-shaped white dorsal spots; full grown, 2 inches.	Forest tent caterpillar *(Malacosoma disstria)*
May to June	Cherry	Gregarious; free feeding, using tent in branch fork when at rest. Caterpillar deep black in general body color, with broad white dorsal stripe and pale blue lateral spots; full grown, 2 to 2½ inches.	Eastern tent caterpillar *(Malacosoma americanum)*
June to October, (a partial second generation)	Red maple	Solitary. Striped, yellowish-green caterpillar with cherry-red head; full grown, 1½ inches.	Green-striped mapleworm *(Anisota rubicunda)*
Mid-May to early June	Elm, birch, maple, oak	Solitary; both species usually present and difficult to distinguish in the field. Vari-colored inchworms; full grown, 1 inch.	Spring cankerworm *(Paleacrita vernata)* Fall cankerworm *(Alsophila pometaria)*
June to early July	Aspen, sugar maple	Solitary. Green inchworms; full grown ¾ inch. Sometimes found with spring and fall cankerworms.	Bruce spanworm *(Operophtera bruceata)*
June to mid-July	Oak, birch	Solitary. Dusky, hairy caterpillar, head with yellow markings; full grown 1½ to 2½ inches.	Gypsy moth *(Porthetria dispar)*
May to September, two generations	Elm, aspen, willow	Gregarious. Black, spiny caterpillar with many white dots; full grown, 2 inches.	Mourning-cloak butterfly — spiny elm caterpillar *(Nymphalis antiopa)*
June to early July	Basswood, elm	Solitary. Bright, yellow inchworms, with black lines; full grown, 1½ inches.	Linden looper *(Erannis tiliaria)*

(Table continued on next page)

Period defoliation is most noticeable	Favored hosts	Description of feeding habits and feeding stages	Insect species
June to mid-July	Basswood, elm, aspen, maple	Solitary; leaves skeletonized early, then complete defoliation. Tufted, creamy-yellow caterpillar with coral-red head; full grown, 1¼ inches.	White-marked tussock moth *(Hemerocampa leucostigma)*
June to October, overlapping larval stages	Elm, maple, oak	Solitary. Large green caterpillar, with reddish-brown head; full grown, 3 inches.	Polyphemus moth *(Antheraea polyphemus)*
July to August	Oak (white)	Gregarious when young, solitary later. Jet black caterpillar with orange stripes; full grown, 1¾ inches.	Orange-striped oakworm *(Anisota senatoria)*
July to August	Oak, birch, basswood	Gregarious. Moderately hairy, black caterpillar with four narrow lengthwise pale yellow stripes, yellow-necked; full grown, 2 inches.	Yellow-necked caterpillar *(Datana ministra)*
July to August	Walnut, hickory, butternut	Gregarious. Grayish-black striped caterpillar clothed in long, grayish hairs; full grown, 2 inches.	Walnut caterpillar *(Datana integerrima)*
July to late August	Sugar maple, beech	Solitary; heaviest feeding in upper crown. Yellowish-green smooth caterpillar, with reddish head and a reddish-brown saddle on body; full grown, 1½ inches.	Saddled prominent *(Heterocampa guttivitta)*
July to October, overlapping larval stages	Cherry, boxelder	Solitary. Large bluish-green caterpillar; body with coral-red tubercles; full grown, 3 to 4 inches.	Cecropia moth *(Hyalophora cecropia)*
July to October, overlapping larval stages	Oaks, basswood	Solitary. Yellowish-green smooth caterpillar, with variable reddish markings; full grown, 1½ inches.	Variable oak leaf caterpillar *(Heterocampa manteo)*
July to October, overlapping larval stages	Oak (white)	Gregarious when young, solitary later. Yellow, smooth caterpillar with orange head, *five* black dorsal lines on abdomen and orange-red hump on eighth segment; full grown, 1¾ inches.	Red-humped oakworm *(Symmerista canicosta)*
August to September	Sugar maple	Gregarious when young, solitary later. Yellow, smooth caterpillar with orange head, *three* black dorsal lines on abdomen and orange-red hump on eighth segment; full grown, 1¾ inches.	Orange-humped mapleworm *(Symmerista leucitys)*
Summer	Elm, red maple	Solitary; complete defoliation by gray and brown caterpillars; full grown, 1½ inches.	Elm spanworm *(Ennomos subsignarius)*

SAWFLIES (HYMENOPTERA)			
Late May to late June	Ash	Solitary. Yellowish- to greenish-white sawfly larva, with brownish head; full grown, ¾ inch.	Brown-headed ash sawfly *(Tomostethus multicinctus)*
Late May to late June	Ash	Solitary. Yellowish- to greenish-white sawfly larva, with shiny black head; full grown, ¾ inch.	Black-headed ash sawfly *(Tethida cordigera)*
Late June to August	Mountain ash	Gregarious. Yellowish sawfly larva with black spots of uneven size and shape; head yellowish orange; full grown, ¾ inch.	Mountain-ash sawfly *(Pristiphora geniculata)*
June to October, overlapping larval stages	Elm, willow	Solitary; usually coiled when not feeding. Pale yellow sawfly larva with longitudinal black stripe and wart-like growths; full grown, 1¾ inches.	Elm sawfly *(Cimbex americana)*
July to October, overlapping larval stages	Willow, aspen	Gregarious. Slate-black sawfly larva, with row of lateral yellow spots; full grown, ¾ inch.	Willow sawfly *(Nematus ventralis)*
August to September	Birch	Gregarious. Yellowish sawfly larva with six rows of black spots on back and a reddish-yellow head; full grown, ¾ inch.	Birch sawfly *(Arge pectoralis)*
BEETLES (COLEOPTERA)			
May to August	Aspen, willow	Shotholes by blackish beetles in the developing leaves. Gregarious larvae skeletonize the lower leaf surface. Full-grown larvae about ⅜ inch long.	Cottonwood leaf beetle *(Chrysomela scripta)*
Spring to early summer	Oak, birch, aspen	Solitary; feeding by adults, not larvae; portions of leaves cut out. Light to dark brown, hard-shelled beetles, ⅜ to 1 inch long.	Leaf chafers — June beetles *(Phyllophaga* spp.*)*
Late June to July	Elm	Solitary; holes chewed in leaves by yellowish-green beetles about ¼ inch long.	Elm leaf beetle *(Galerucella luteola)*
Late spring through summer	Siberian pea	Solitary; feeding by adults, not larvae. Gray, brown, or black soft-bodied beetles, ½ to 1 inch long.	Blister beetles *(Meloidae)*
WALKINGSTICK (ORTHOPTERA)			
Late June to Mid-July	Red oak, basswood, cherry	Trees defoliated by nymphs and adults. Nymphs pale green, darkening to brown at maturity; adults long-legged, wingless; up to 3 inches long.	Walkingstick *(Diapheromera femorata)*

DEFOLIATORS

Injury by defoliators can be classified as: (1) complete or partial destruction of the leaves by free-feeding insects, (2) mining or skeletonizing of the upper or lower leaf surfaces, and (3) leaf rolling, webbing, or tenting of the foliage or branches. Feeding by the free-feeding caterpillars is most noticeable in the later stages of caterpillar development. Under epidemic conditions many thousands of acres of one tree species or of a favorable forest type, even including the underbrush, may be completely denuded. Defoliation being the end result, collection and examination of the feeding insects is necessary for determination of the exact species. The information in table 1 should be sufficient to allow field identification of most of the species in this group. The other types of defoliators, leaf miners, skeletonizers, leaf rollers, web-makers, and tent-makers cause characteristic damage symptoms and are included in the general key.

Free-Feeding Species[1]

Forest Tent Caterpillar

(Malacosoma disstria)

Hosts. — Aspen and sugar maple are the preferred hosts in their forest type areas. Other favored hosts, particularly when growing with aspen and sugar maple, are basswood, oak, cherry, birch, and elm. Red maple is avoided. In outbreak conditions, late-stage caterpillars will feed on brush growth and even garden crops.

Injury. — Heavy feeding causes a decline in vigor, dieback of twigs and branches, and reduction in radial increment. Continued severe defoliation for several years will kill trees on poor sites. Maple sugar orchards may be seriously weakened and the quality and quantity of sap affected. The caterpillars congregate on the trunk or larger branches when at rest or during molts (fig. 1, left) and a silken mat, not a tent, is formed there. Region-wide outbreaks occur at 10- to 15-year intervals.

Description. — The moths are stout bodied and a light buff brown. The wing expanse is about 1½ inches, and the forewings have two dark, oblique lines. When hatched, the caterpillars are black, hairy, and less than a half inch long. As they develop, the hairs disappear and a bluish color becomes evident along the sides of the body. When full-grown they have a row of keyhole spots along the back (fig. 1, right). The egg masses, which encircle the twigs, are cylindrical and have flat ends.

Green-Striped Mapleworm

(Anisota rubicunda)

Hosts. — Red maple is the preferred host in the Lake States; but sugar maple, oak, and boxelder may also be defoliated when the insect population is large.

Injury. — Defoliation over relatively large areas occurs periodically. Little permanent damage has been reported, but heavy feeding causing complete loss of foliage, followed by a partial second-generation feeding on the second crop of leaves, will result in reduction of tree growth.

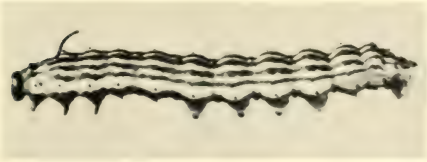
Decription. — The moths have a yellowish body with the underside pinkish. The wing expanse is 1½

[1] *See item 2 in key and table 1.*

F-506692

FIGURE 1. — *Left,* forest tent caterpillars at rest on the trunk and branches of an aspen. *Right,* a full-grown caterpillar; note the keyhole-shaped spots along the back (photo courtesy Quetico-Superior Wilderness Research Center.)

to 2 inches; the forewings are rose colored with a broad yellowish band. The pale yellowish-green, full-grown caterpillar (fig. 2) bears seven dark green or blackish longitudinal lines. There are two long slender horns on the thorax and four prominent dorsal spines at the tail.



F-500799

FIGURE 2. — The green-striped maple-worm; note the prominent stripes and the thoracic horn.

Orange-Striped Oakworm

(Anisota senatoria)

Hosts. — Oaks, especially the white oaks.

Injury. — Although heavy populations are usually confined to local areas, serious defoliation may occur over large acreages; and when this continues for several years, tree vigor is reduced and some trees die.

Description. — The moths are tan or yellowish in general body and wing colorations; the forewings, which have an expanse of about 2 inches, are speckled with black dots and have a large white spot near the middle. The jet-black, full-grown caterpillars (fig. 3) have two longitudinal orange stripes along the back and two similarly colored wavy stripes along the sides. There are a pair of stiff, slender, black spines on the thorax and small, sharp, black spines on the body segments.

Variable Oak Leaf Caterpillar

(Heterocampa manteo)

Hosts. — Oaks are favored. Basswood, beech, birch, and American

FIGURE 3. — The orange-striped oakworm. Note the various spines. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

elm are frequently defoliated, and other hardwood species are occasionally attacked.

Injury. — The foliage of all sizes of trees is fed on in a characteristic manner (fig. 4, bottom). Occasionally sporadic outbreaks develop, populations increase enormously, and heavy defoliation occurs. Since much of the feeding is late in the season, little damage results unless an infestation persists for several years. When this occurs, tree vigor and growth are affected.

Description. — The moths are ashy gray and have a wing expanse of about 1½ inches. The forewings have three dark, wavy, and diffused lines. Although the general body coloration of the caterpillars is yellowish green, the variable markings (fig. 4, top) — chiefly reddish brown to black and creamy white — are

F-496929, 496930

FIGURE 4. — *Bottom,* characteristic feeding pattern of the variable oak leaf caterpillar. *Top,* the variable markings on the full-grown caterpillars.

distinctive and serve as a good means for identification.

Saddled Prominent

(Heterocampa guttivitta)

Hosts. — Beech and sugar maple; when abundant it feeds also on many other hardwood species and even on spiraea and blackberry.

Injury. — In the early stages the caterpillars are skeletonizers, but as they develop they eat all but the principal veins. Two consecutive

FIGURE 5. — Saddled prominent caterpillars, showing the characteristic saddle. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

years of heavy defoliation may kill trees or will kill a large portion of the crowns. When sugar maples are severely defoliated, the quantity and quality of sap and sugar decrease.

Description. — The moths are brownish gray with a wing expanse of about 2 inches; the forewings have indistinct and variable dark crossmarkings. Although the full-grown caterpillars are generally yellowish green, they may vary in color. The reddish-brown saddle (fig. 5) is very prominent — hence the common name.

Yellow-Necked Caterpillar
(Datana ministra)

Hosts. — Oak, birch, basswood.

Injury. — The early stage caterpillars skeletonize the lower leaf surface; as they develop they devour the entire leaf and very often only the stem remains. They feed in large colonies, and as a general rule the greatest damage occurs on small trees.

Description. — The moths are brownish and have a wingspread of about 2 inches. The forewings have numerous irregular, dark hues. The full-grown caterpillars are distinctly striped lengthwise, and the body is sparsely clothed with long, white hairs. The caterpillars are gregarious (fig. 6) and when disturbed they elevate both ends of the body.

FIGURE 6. — A colony of half-grown yellow-necked caterpillars. (Photo courtesy of the Illinois Natural History Survey.)

Walnut Caterpillar
(Datana integerrima)

Host. — Walnut.

Injury. — The early stage caterpillars skeletonize the lower leaf surface and later consume the entire leaf. Like the yellow-necked caterpillars, they feed in large colonies; and when they are abundant, isolated trees or trees in small groups are subject to heavy feeding. Large groves of trees in forest stands are not so likely to be heavily defoliated.

Description. — The moths are brownish gray and have a wingspread of nearly 2 inches. The forewings are marked by curving, transverse, dark lines. The young caterpillars are red; but when full-

FIGURE 7. — Half-grown walnut caterpillars. Note the grayish-white hairs. (Photo courtesy of the Illinois Natural History Survey.)

grown they are black, indistinctly lined, and covered with numerous long, grayish-white hairs (fig. 7).

Red-Humped Oakworm
(Symmerista canicosta)
Orange-Humped Mapleworm
(Symmerista leucitys)

Hosts. — Oak, chiefly white oak and bur oak; and sugar maple.

Injury. — The early larval stages are gregarious and skeletonize the leaves. As the caterpillars develop, they scatter and consume all but the midribs of leaves. Generally infestations are local, and occasionally the caterpillars are sufficiently numerous to completely defoliate trees.

FIGURE 8. — *Top*, the red-humped oakworm. *Bottom*, pupation in rolled oak leaves. (Photos courtesy of The Connecticut Agricultural Experiment Station.)

Description. — The moths of each species are ash gray with a wing expanse of about 2 inches. The forewings have a whitish streak along the front margin. The full-grown caterpillars are yellowish; the distinguishing characteristic is five black dorsal lines for the oakworm (fig. 8, top) and three black, dorsal lines for the mapleworm. These two species have been confused with the closely related *Symmerista albifrons* but apparently are more northerly in general distribution. Pupation takes place in a rolled leaf (fig. 8, bottom).

White-Marked Tussock Moth
(Hemerocampa leucostigma)

Hosts. — Basswood, elm, aspen, maple. Although a general feeder, it is primarily a pest of shade trees.

Injury. — The early stage caterpillars skeletonize the lower leaf surface; as they develop they eat holes in the leaves and finally devour all but the midrib and main veins.

Description. — The wingless females are hairy, light brown to gray, and about one-half inch long. The male moths are grayish brown to reddish brown and have a wingspread of about 1¼ inches. The full-grown caterpillars can be identified by the coral-red head, two long pencils of black hairs at the front and one at the rear, and a dorsal, white brush or tuft on the first four abdominal segments (fig. 9).

F-504096

FIGURE 9. — Caterpillars of the white-marked tussock moth, showing the prominent pencils and tufts.

Gypsy Moth
(Porthetria dispar)

Hosts. — Oak, birch, aspen, and basswood are favored. However, in an outbreak the foliage of most hardwoods and even of some conifers will be eaten. In the Lake States, up to the present time, this insect has been confined to southeastern Michigan. There are large acreages of susceptible forest in the central hardwoods type throughout the north-central region, and there should be constant surveillance for evidence of this pest. It can exist in small numbers in farmwoods or in an extensive stand for some years without causing noticeable defoliation and then suddenly develop to outbreak status.

Injury. — This is an imported insect which, to all intents and purposes, has reached the status of a native insect in that it is subject to periodic increases and decreases in populations. One complete defoliation will not kill trees, but over a period of years, even in thrifty stands, successive defoliations will reduce vigor. When rainfall is deficient during an outbreak, the way

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FIGURE 10. — *Left*, a gypsy moth egg mass covered with hairs from the body of the female moth. *Right*, a full-grown caterpillar.

is opened for attack by secondary insects and tree mortality may be hastened.

Description. — The female moths are nearly white with wavy, black bands across the forewings. Although they have a wing expanse of 2 inches, they are heavy bodied and cannot fly. The male moths are smaller and are dark brown with blackish bands across the forewings. They are slender and, in contrast to the females, are good fliers. The abdomen of the female is covered with yellow hairs that are shed and used to cover the egg mass (fig. 10, left), which is deposited on the bark of trees or under stones and debris on the ground. They are very conspicuous when abundant and can be used in surveys to determine future larval populations. The full-grown hairy caterpillars are about 2 inches long. The dorsal surface of the body, behind the head, has a double row of blue spots on the first five segments and a double row of dark red spots on the next six segments (fig. 10, right).

Spring Cankerworm
(Paleacrita vernata)
Fall Cankerworm
(Alsophila pometaria)
Bruce Spanworm
(Operophtera bruceata)

Hosts. — Elm is probably the preferred host, but birch, maple, and oak may also be heavily defoliated by the cankerworms. Aspen and sugar maple are preferred by the spanworm.

Injury. — The larvae, in the early stages, skeletonize the tender leaves at the branch tips. The older stages eat the leaves partially, but in an outbreak all but the midribs and larger veins may be devoured (fig. 11). As a rule, heavy feeding occurs at intervals of about 15 years and may last for 3 years. Under drought conditions an outbreak may result in reduced tree vigor and radial increment, but forest stands are usually not seriously affected. The early stage Bruce spanworms feed on the blossom buds, and the older stages feed in the same manner as the spring and fall cankerworms.

FIGURE 11. — Feeding damage on elm by the spring cankerworm. (Photo courtesy of the Illinois Natural History Survey.)

Description. — The two cankerworm species are closely associated and look somewhat alike. The female moths are wingless and are about one-third inch long; those of the spring species have a black dorsal stripe, while those of the fall species are uniformly gray. The males of both species are brownish gray, but the fall species is darker. The fall cankerworm lays its eggs in the fall, the spring species in the spring. They hatch about the same time, however, and the caterpillars develop, even on the same branch. Each species varies greatly in coloration and markings, and careful observations are necessary for species separation. The caterpillars of the fall species have three pairs of abdominal prolegs, while those of the spring species have two. The wingless females of the Bruce spanworm are light brownish gray and are about the same length as those of the cankerworms. The male moths are pale grayish with brownish flecks. The full-grown larvae are about one inch long and are bright green with yellowish-white lateral stripes (fig. 12).

Elm Spanworm

(Ennomos subsignarius)

Hosts. — Elm, basswood, red maple, and birch.

Injury. — The feeding damage is similar to that caused by the cankerworms. Large areas, particularly swampland, are periodically heavily defoliated. The caterpillars complete

FIGURE 12. — A full-grown Bruce spanworm. (Photo courtesy of Canada Department of Forestry.)

development in June, and the pupae may be found between leaves spun together or in bark crevices.

Description. — The female moths are white, with a wing expanse of about 1½ inches; they are also called snow-white linden moths. Unlike the moths of the cankerworms, they are winged. The full-grown caterpillars are about 1½ inches long and are gray and brown in general color with irregular markings. They closely resemble elm twigs.

Linden Looper

(Erranis tiliaria)

Hosts. — Basswood and elm are preferred; but oak, birch, maple, and other hardwoods are attacked when the insect is abundant.

Injury. — Typically the feeding damage is similar to that caused by the spring and fall cankerworms in that the individual leaves are partially eaten. When an outbreak occurs, almost all the foliage is destroyed. Usually, however, such conditions are local and short-lived and are reduced in intensity by weather and other factors.

Description. — The wingless females are about one-half inch long and vary in color from brown to gray with two rows of black dorsal spots. The male moths are buff colored and have a wingspread of nearly 2 inches. The bright yellow caterpillars (inchworms or loopers) have 10 wavy, black lines along the back, with the outer one on each side heavier.

Cecropia Moth

(Hyalophora cecropia)

Hosts. — Cherry and boxelder, chiefly in the Northern Great Plains.

Injury. — Sometimes called giant silkworms, the caterpillars are solitary feeders. Generally they occur singly or in small numbers. By the late stages the feeding injury is more noticeable than injurious, but it is sometimes serious in shelterbelt plantings. There are overlapping larval stages so that defoliation may be noticeable from July to October.

Description. — The moths are brownish with rusty-red and grayish-white markings and a wingspread of 5 to 6 inches. There is a conspicuous crescent - shaped, white spot near the center of all four wings and also a white crossband bordered with red. The full-grown caterpillars, often 4 inches long and a half inch or more in diameter, are very conspicuous, the body bearing four coral-red, dorsal tubercles on the thorax and 15 dorsal, yellow tubercles on the abdomen (fig. 13).

FIGURE 13. — A cecropia caterpillar. Note the various tubercles. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

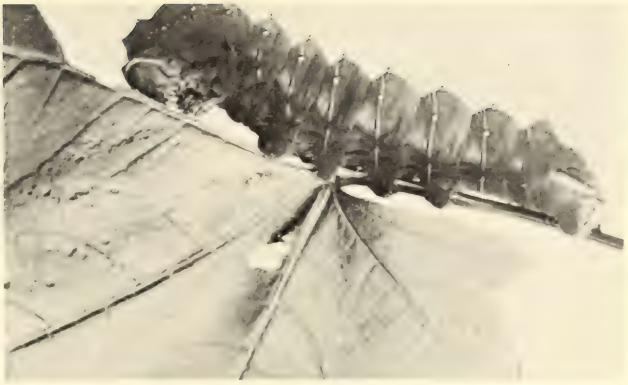

FIGURE 14. — A polyphemus caterpillar; the orange - to - reddish tubercles are conspicuous. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

Polyphemus Moth
(Antheraea polyphemus)

Hosts. — Elms, maples, and oaks, chiefly in the Northern Great Plains.

Injury. — This is another of the giant silkworms; its feeding habits are similar to those of the cecropia moth. Overlapping larval stages result in noticeable defoliation from June to October.

Description. — The moths are brownish yellow with a wing expanse of 4 to 6 inches. There is a transparent eyespot on each wing, those on the hind wings having a dark border. The full-grown caterpillars are often 3 inches long and a half inch in diameter. They are ornamented with small, orange-to-reddish tubercles from which rise one to three straw-colored bristles (fig. 14). The last body segment bears a V-shaped, purplish design.

Mourning-Cloak Butterfly
(Spiny Elm Caterpillar)
(Nymphalis antiopa)

Hosts. — Elms, aspens, willow, and hackberry.

Injury. — The caterpillars feed in colonies, eating all of the leaf tissue but the larger veins. They are more frequently found in the upper portion of the tree, and whole branches may be defoliated. There are two generations annually, but the defoliation by the first generation is the more noticeable.

Description. — The moths are deep brownish purple, with the outer edges of the wings banded with creamy yellow; inside these bands is a row of blue spots. The wing expanse is from 2 to 3 inches. The full-grown caterpillar is black with white raised dots and a conspicuous row of red spots down the middle of the back. Each body segment has a transverse row of black branched spines (fig. 15).

Birch Sawfly
(Arge pectoralis)

Host. — Paper birch.

Injury. — Trees are partially or wholly defoliated during August and September. The larvae are gregarious and cling to the edge of the leaves while feeding. When abundant, they may defoliate trees heavily over relatively large areas.

Description. — The adults are about three-eighths inch long, with semi-membranous wings. The most characteristic feature of the adults is the three-segmented antennae. The full-grown larvae (fig. 16) are about three-fourths inch long; they are yellowish with six rows of conspicuous black spots down the back and have reddish-yellow heads.

FIGURE 15. — Spiny elm caterpillars (of the mourning-cloak butterfly). (Photo courtesy of The Connecticut Agricultural Experiment Station.)

Elm Sawfly
(Cimbex americana)

Hosts. — Elm, willow, and occasionally basswood, birch, maple, and aspen.

Injury. — The leaves may be partially or wholly devoured, even the veins, by the larvae. The adults emerge from late May to August, so that larvae may be found until October. The adults sometimes chew the thin, tender bark of twigs, girdling and killing them and causing noticeable crown injury. This insect is not common in the forest, but is more important as a shade-tree pest.

Description. — The adult females are among the largest of our sawflies, ranging from ¾ to 1 inch long. Their robust bodies are steel blue with oval yellow spots on each side. The semitransparent wings are smoky brown in general color, and the wingspread is about 2 inches. The black dorsal line on the pale yellowish-green larvae is an excellent means of recognition. When at rest, they coil up, like snails, around a twig (fig. 17).

Brown-Headed Ash Sawfly
(Tomostethus multicinctus)
Black-Headed Ash Sawfly
(Tethida cordigera)

Hosts. — Ash.

Injury. — Feeding from the undersurface, the early stage larvae eat shotholes in the leaflets. When the larvae are abundant, the later stages devour the leaflets completely — often leaving only the main stem of the compound leaf.

FIGURE 16. — Larvae of the birch sawfly. (Photo by D. C. Anderson, courtesy Canada Department of Forestry.)

FIGURE 17. — An elm sawfly larva, much enlarged, in the typical coiled-up position. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

Description. — The adults of the two species look much alike and range from ¼ to ⅜ inch long. They are black and have semi-membranous wings (fig. 18). The larvae are also very similar; as their common names imply, the species can be separated by the color of their heads — brown or black.

Willow Sawfly
(Nematus ventralis)

Hosts. — Willow and aspen.

Injury. — The early stage larvae feed in compact colonies, making small holes in the leaves. As they develop, each leaf except the midrib is eaten. The most severe damage occurs on willow along streambanks, but aspen will also be attacked.

Description. — The sawflies are brownish black with yellowish-white markings. They are about one-third inch long and have membranous wings with a spread of about half an inch. The developing larvae are greenish black with a row of large yellow spots on each side of the body; when full grown, the general body color is slate black, and the spots are somewhat faded. They rear back when disturbed (fig. 19).

Mountain-Ash Sawfly
(Pristiphora geniculata)

Host. — Mountain ash.

Injury. — The early stage larvae skeletonize the leaves between the veins; as they develop they devour all but the midrib. This species feeds in colonies, usually eating all the leaves on one small branch before moving to another branch. Scattered trees in a forest stand are as subject to defoliation as ornamental trees.

Description. — The sawflies are stout and shiny black, and vary from 3/16 to 5/16 inch in length, the males being smaller than the females. The full-grown larvae are yellow, with numerous black spots on the body segments, and are about ¾ inch long (fig. 20).

F-504122

FIGURE 18. — The brown-headed ash sawfly; 1, adult female; 2, adult male; 3, larvae.

F-504085
FIGURE 19. — Larvae of the willow sawfly, showing the typical rearing back when disturbed.

FIGURE 20. — Full-grown larvae of the mountain-ash sawfly. (Photo by D. C. Anderson, courtesy of Canada Department of Forestry.)

Walkingstick
(Diapheromera femorata)

Hosts. — Oaks of the red oak group, basswood, and cherry are the preferred hosts. Other hardwoods growing with these hosts may also be attacked.

Injury. — Defoliation is especially noticeable where the favored hosts are concentrated. Two years are required for development, and there are even-year and odd-year broods in various parts of the region. Unless both broods are present in a particular locality, defoliation will occur in alternate years. These insects are wingless and lateral spread is slow.

Description. — Development occurs through incomplete metamorphosis, there being no change in body form as in pupation. In the early stages the nymphs are greenish; as they develop they change to dark green, gray, or brown. When full grown, the walkingsticks measure up to 3 inches in length, the females being larger than the males (fig. 21).

June Beetles (Leaf Chafers)
(Phyllophaga spp. particularly)

Hosts. — All the common hardwoods and shrubs around nurseries and fields and in woodlots and shelterbelts. Among the tree species the oaks, birches, and aspens are preferred.

F-504094
FIGURE 21. — Male (smaller) and female walkingsticks.

Injury. — While damage to coniferous seedlings and transplants by the larvae (white grubs) is the more important type of injury, that caused by adults feeding on the foliage of forest trees may also be serious. The heaviest damage occurs in the spring when the leaves are tender. Much of the feeding is at night. When beetle populations are high, this feeding damage may be very noticeable. Although the genus *Phyllophaga* is considered the most important, other genera are involved and the generic feeding patterns are distinct. In some cases the leaves are eaten across the main veins at the tip; in others circular or oval holes are eaten out of the margins; and in still others holes are eaten inside the margins and between the veins. Where heavy feeding occurs, pieces of the leaves can usually be found on the forest floor below the feeding area. This is in contrast to feeding by insects such as the forest tent caterpillar, which can be identified by the presence of frass on the leaves or on the forest floor.

Description. — The robust beetles are ½ to 1 inch long and vary in color from light brown through dark brown to brownish black. They have powerful biting jaws (mandibles), which are used in cutting the leaves. In a typical feeding position the legs on one side of the body are on the upper surface of the leaf and those on the other side are on the lower surface, with the edge of the leaf between the mandibles (fig. 22).

Blister Beetles
(Meloidae)

Hosts. — Shrubs and young hardwoods in nurseries, ornamental plantings, and shelterbelts.

F-506528
FIGURE 22. — Typical feeding damage on paper birch foliage by a June beetle.

F-500803
FIGURE 23. — A blister beetle feeding on the leaves of the Siberian pea shrub.

Injury. — Although the leaves, as a rule, are partially eaten at the margins, heavy populations will cause noticeable defoliation, particularly on windbreaks in nursery areas.

Description. — The adults are ½ to 1 inch long and vary in color, generally being gray or black (fig. 23). The abdomen often is large and extends beyond the ends of the wingcovers. The larvae of some species are predatory on grasshopper eggs in the soil.

Webworms, Tent-Makers, Leaf Rollers

Eastern Tent Caterpillar (See Key, 12)
(Malacosoma americanum)

Prairie Tent Caterpillar (See Key, 13)
(Malacosoma lutescens)

Host. — Cherry.

Injury. — Defoliation of branches and, under outbreak conditions, of entire trees. Tents are spun in the branch forks during May and June (fig. 24); they are used chiefly as resting places, and the caterpillars move out to feed on the nearby foliage. This insect is often confused with the forest tent caterpillar; however, the latter does not spin a tent and the preferred hosts are aspen and sugar maple.

Description. — The moths are dull reddish brown with a wingspread of 1½ to 2 inches. The forewings have two nearly parallel oblique white bars. The full-grown caterpillars are 2 inches long, and are deep black in general body color

F-404155
FIGURE 24. — The tent of the eastern tent caterpillar on black cherry.

with a rather broad white dorsal stripe. The egg masses, cemented on small twigs, form a dark oval mass rounded at the ends and usually only partially surround the twig. Those of the forest tent caterpillar are deposited in the same manner, but are flat at the ends and completely encircle the twigs. The closely related prairie tent caterpillar is of importance on chokecherry in shelterbelt areas. The tents are somewhat similar to those made by the eastern tent caterpillar. The full-grown caterpillars are brown, with a row of elliptical blue spots down the center and two orange spots on each segment. The sides have pale orange lines and spots.

Fall Webworm (See Key, 13)
(Hyphantria cunea)

Hosts. — Elm, ash, aspen, cherry, and willow are the preferred forest species in the Lake States.

Injury. — The caterpillars feed in colonies in conspicuous webs, which usually enclose all the foliage on one limb (fig. 25). When the insect is very abundant an entire tree may be enclosed. In the early stages, the caterpillars skeletonize the leaves; as they develop, all but the midribs are eaten. In the southern and warmer part of the Lake States there may be two generations; in the north there is one. The tents in the first generation are often confused with those of the tent caterpillars, which are formed only in the forks of limbs and branches.

F-505763

FIGURE 25. — Defoliation and the webbing caused by the fall webworm.

Description. — The moths vary in color from pure white to white with black or brown spots on the wings; the wing expanse is about 1¼ inches. The full-grown caterpillars are about 1 inch long. There is considerable color variation, but generally they are pale yellow or green with a broad dark stripe down the back and a yellow lateral stripe. The body is covered with gray or red hairs which arise from black and orange warts.

Oak Webworm (See Key, 13)
(Archips fervidanus)

Hosts. — Red, black, and scarlet oaks.

Injury. — The caterpillars are gregarious and feed on the foliage of sprout growth and seedlings in webs often a foot to a foot and a half long and several inches in diameter (fig. 26). These webs may enclose all the foliage at the tips of branches or at the tops of the trees. They are noticeable by late June.

Description. — The moths are brownish with a wing expanse of about three-fourths inch and with darker patches on the light-brown forewings. The full-grown caterpillars are black headed, gray green in body color, and about three-fourths inch long.

Ugly-Nest Caterpillar (See Key, 13)
(Archips cerasivoranus)

Hosts. — Chokecherry and black cherry.

F-504083
FIGURE 26. — A mass of leaves webbed together by the oak webworm.

Injury. — The caterpillars are gregarious and construct a web, tying the twigs and leaves into a dense nest and enlarging it as they feed on the foliage. Individual nests may be a foot or more long (fig. 27). Under heavy population conditions the nests may be numerous and an entire small tree may be enclosed.

Description. — The moths are dull orange, with a wing expanse of about 1 inch and reddish-brown speckling on the forewings. The full-grown caterpillars are about three-fourths inch long, black headed, and yellow bodied. Pupation occurs within the web, and prior to moth emergence the pupae wriggle part of the way out of the nest. The cast pupal skins remain attached to the nest and are a good indication that feeding has been completed.

FIGURE 27. — Nest of the ugly-nest caterpillar on pin cherry. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

Maple Leaf Rollers (See Key, 14)
(Sparganothis acerivorana)
(Acleris chalybeana)

Maple Webworm (See Key, 13)
(Tetralopha asperatella)

Hosts. — Sugar maple, red maple, and silver maple; and sometimes aspen, beech, and oak.

Injury. — A few years ago a startling amount of mortality of sugar maple appeared in northern Wisconsin. All sizes of trees died — from small saplings to mature trees. Although the causes leading up to this condition are not completely known, it has been established that a complex of defoliating insects, each species hitherto considered of minor importance, was the major cause. The insect injury appeared as leaf rolling and webbing from mid-May to mid-August. The caterpillars of *Sparganothis acerivorana* appear in May as solitary feeders, rolling the leaves and using them as resting places from which they move out to feed on adjacent leaves (fig. 28, top). The caterpillars of *Acleris chalybeana,* also solitary feeders, attract attention in June, rolling some leaves and feeding in them but also in those already rolled by the first species. The webworms are the last to be apparent; gregarious, they feed in the leaves rolled by the leaf rollers, skeletonizing the inner surface (fig. 28, bottom). After a brief period they web groups of leaves and feed on them, sometimes enclosing a whole branch. These webworms, appearing late in the season, were responsible for the major portion of the damage in the northern Wisconsin outbreak, by reducing the amount of stored food necessary for adequate early tree growth the next season.

Description:
Sparganothis acerivorana: The moths are reddish yellow with reddish brown spots, and with a wingspread of about 1 inch. The full-grown caterpillars are yellowish green with a tan head and are about 1 inch long.

FIGURE 28. — *Top,* leaf rolled by a maple leaf roller. *Bottom,* larvae of the maple webworm in a web. (Photos courtesy of the University of Wisconsin.)

Acleris chalybeana: The moths are grayish and have a wingspread of about seven-eighths inch. The full-grown caterpillars are light green and are about seven-eighths inch long.

Tetralopha asperatella: The moths are powdery gray and have a wingspread of nearly 1 inch. The full-grown caterpillars vary in color from yellow to green and brown to nearly black. They are about three-fourths inch long.

Fruit-Tree Leaf Roller (See Key, 14)
(Archips argyrospilus)

Hosts. — Oak, elm, aspen, ash, and soft maple.

Injury. — The early stage caterpillars feed on the swelling buds

FIGURE 29. — The leaf rolling habit of the fruit-tree leaf roller. (Photo courtesy of the Canada Department of Agriculture.)

in May, injuring the terminal growth. Later they feed on the unfolding leaves, rolling and webbing them (fig. 29). When there are large populations, the terminal growth suffers considerable damage.

Description. — The moths are brownish. The wingspread is about seven-eighths inch, and the forewings have a creamy or straw-colored mottling. The full-grown caterpillar is about three-fourths inch long, and has a light-green body and a dark-brown or black head.

Large Aspen Tortrix (See Key, 14)
(Choristoneura conflictana)

Host. — Aspen.

Injury. — The gregarious, first-instar caterpillars web two leaves together in July and August and skeletonize the touching surfaces. They hibernate as second-instar larvae in sheltered places such as bark crevices or under loose bark. Activity is resumed in the spring and, as solitary feeders, they bore into the buds and feed on the tissues of the expanding leaves. As the caterpillars develop, the leaves are rolled and whole portions are eaten. When the insects are abundant, heavy defoliation occurs. Pupation takes places in the rolled leaves (fig. 30). The moths emerge in late June.

Description. — The moths are light gray and have a wing expanse of 1 to 1¼ inches with darker patches on the forewings. The full-grown caterpillars are about seven-eighths inch long and are dark green to almost black in general body color.

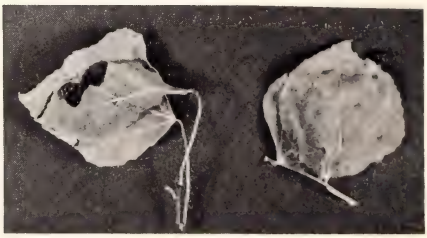

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FIGURE 30. — Large aspen tortrix pupae in rolled leaves.

Aspen Leaf Roller (See Key, 14)
(Anacampsis innocuella)

Hosts. — Aspens.

Injury. — The solitary-feeding caterpillars roll the leaves, the injury becoming noticeable in the

FIGURE 31. — The aspen leaf roller. (Photo courtesy of the Ohio Agricultural Experiment Station.)

upper crown about the middle of May. Early in the season single leaves are rolled (fig. 31); later two or more leaves may be rolled together. Early stage larvae may damage the opening buds. When nearly full grown, the larvae sever the petioles and the leaves drop to the ground where feeding and development are completed.

Description.—The moths are ashy gray with a wing expanse of about seven-eighths inch. The full-grown larvae are about five-eighths inch long and have a dark-brown head. They are translucent, and the green food shows through the body wall.

Basswood Leaf Roller (See Key, 14)
(Pantographa limata)

Host. — Basswood.

Injury. — The apical half of each leaf is rolled into a tube where the caterpillar feeds and develops (fig. 32). This feeding occurs during the

FIGURE 32. — A basswood leaf rolled by the basswood leaf roller. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

latter part of the summer; and even though the insect is often abundant, complete defoliation seldom occurs and damage is of little consequence.

Description. — The moths have a wingspread of more than 1 inch and are pale yellowish white with olive or brown markings. The full-grown caterpillars are bright green and about 1 inch long.

Leaf Miners and Skeletonizers

Aspen Leaf Miner (See Key, 14)
(Phyllocnistis populiella)

Hosts. — Aspens.

Injury. — The larvae are sap-feeding leaf miners; their meandering mines on the under leaf surface appear as small tracks (fig. 33). Forest trees are not seriously damaged, but attacked leaves on ornamental trees are conspicuous and sometimes cause concern.

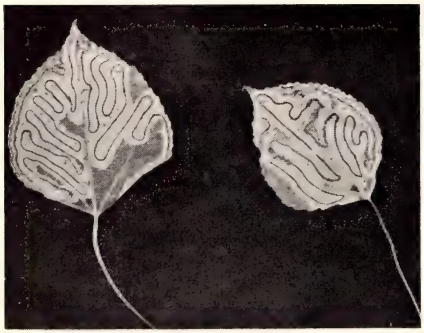

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FIGURE 33. — The small-track mine made by the aspen leaf miner.

Description. — The moths are silvery white and have a wingspread of about one-quarter inch. The larvae are flat in the early instars but become cylindrical when mature. They are white to light cream, and when full-grown are less than one-quarter inch long.

Aspen Blotch Miner (See Key, 14)
(Lithocolletis tremuloidiella)

Host. — Aspen.

Injury. — Irregularly shaped blotchy tentlike mines are made in the leaves in June and early July and again in August. The mines may be nearly three-fourths inch long and half as wide, and several may develop in each leaf. They are somewhat similar to those made by the solitary oak leaf miner but the individual mines are not so distinct. The upper surface of the mines is paler than the surrounding areas. The heaviest attack is on young trees or in the lower crown of larger trees. Forest trees usually are not seriously affected, but heavy feeding will cause premature dropping of the foliage.

Description. — The moths are white with brown bands across the forewings. The wingspread is about one-quarter inch. The full-grown caterpillars are dark and about one-fifth inch long.

Solitary Oak Leaf Miner (See Key, 14)
(Cameraria hamadryadella)
Gregarious Oak Leaf Miner (See Key, 14)
(Cameraria cincinnatiella)

Hosts. — Oaks, chiefly in the white oak group.

Injury. — Irregular white blotchy mines just below the upper leaf surface. Although the larvae are solitary feeders, each leaf may have several contiguous mines (fig. 34). The mines are very conspicuous on the foliage of ornamental trees when the insects are abundant, but they are of minor economic importance in the forest. Generally there are two generations of this leaf

F-504082
FIGURE 34. — Oak leaves with the blotchy mines characteristic of attack by the solitary oak leaf miner.

miner annually. The closely related gregarious oak leaf miner causes the same type of injury, but several larvae will feed together in a large brownish-yellow mine; when there are several mines in a leaf, much of the leaf tissue will be destroyed.

Description. — The tiny moths have long, slender, pale forewings with bronze patches; the wing expanse is about one-fourth inch. The larvae are flat and dark yellow; when mature, they are about one-fifth inch long.

Birch Skeletonizer (See Key, 14)
(Bucculatrix canadensisella)

Oak Skeletonizer (See Key, 14)
(Bucculatrix ainsliella)

Hosts. — Paper birch and yellow birch; red oak and black oak.

Injury. — The early larval stages form meandering mines in the leaves (fig. 35, left), and the older larvae skeletonize the lower surface, leaving the upper surface intact. Small flat molting webs are evidence of the presence of larvae. Heavy infestations by the birch skeletonizer result in complete defoliation, but as the greater part of the feeding occurs late in the season growth reduction is not serious. Foliage browning by the oak skeletonizer (fig. 35, right) occurs earlier and heavy feeding will cause some loss of growth.

Description. — The tiny moths of the birch skeletonizer are brown and white; the forewings are brownish with diagonal white bars. The wingspread is about five-sixteenths inch. The moths of the oak skeletonizer are creamy white and are about the same size as the birch species; the forewings have a brown longitudinal band and a purplish-brown spot at the middle of the inner margin. The full-grown larvae of both species are yellowish green and about one-fourth inch long.

Birch Leaf Miner (See Key, 14)
(Fenusa pusilla)

Hosts. — Paper birch, yellow birch, and European white birch.

Injury. — Grayish, discolored, blotchy areas between the upper and lower leaf surfaces. The attacked areas wrinkle and turn

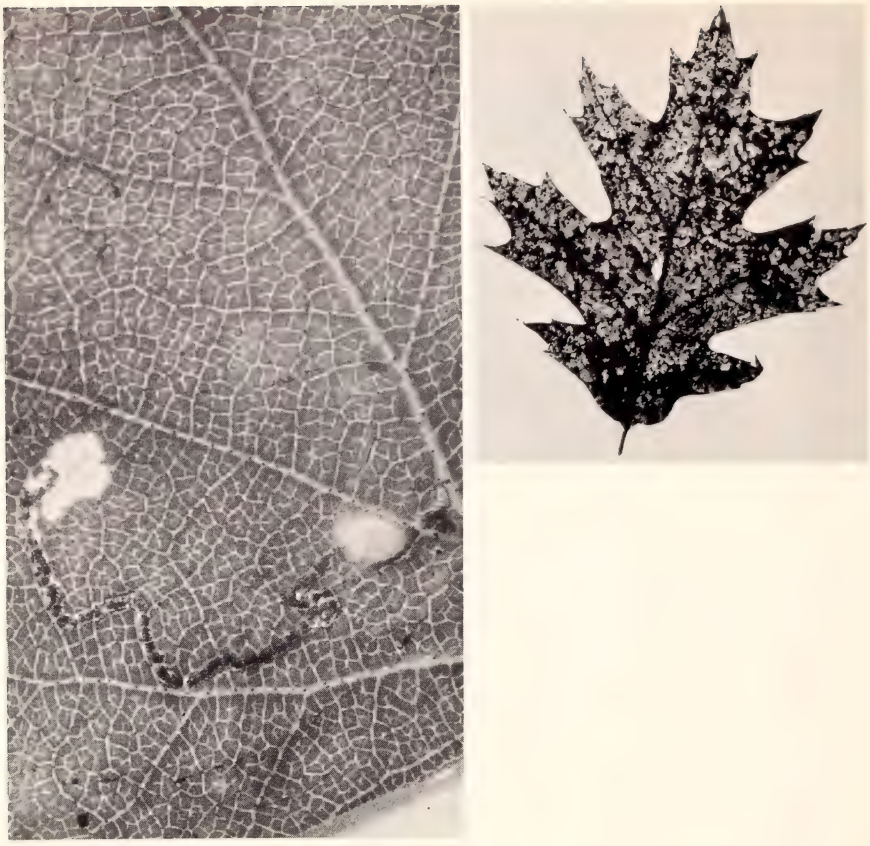

FIGURE 35. — *Left*, a meandering mine made by the birch skeletonizer. (Photo courtesy of The Connecticut Agricultural Experiment Station.) *Right*, an oak leaf mined by the oak skeletonizer. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

brown (fig. 36). The heaviest feeding is generally in the tender new leaves at the tops of the trees or the ends of the branches. There may be two or three generations annually.

Description. — The adults are black sawflies about one-fourth inch long with semi-membranous wings. The full-grown larvae are pale green or white, with black spots on the lower side of the thorax and first abdominal segment.

Elm Leaf Miner (See Key, 14)
(Fenusa ulmi)

Hosts. — English and Scotch elms, occasionally American elm. This insect is an introduction from Europe.

Injury. — Large blotchy or blister-like larval mines are formed between the upper and lower leaf surfaces (fig. 37) in late May and early June. Several larvae may be in one common mine. There is one generation annually. Small trees are most seriously injured, but large trees may also be heavily infested.

FIGURE 36. — Leaves mined by the birch leaf miner. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

In severe infestations the leaves fall prematurely.

Description. — The adults are sawflies, very similar in appearance to those of the birch leaf miner. The legless, flattened larvae are white with a greenish cast and have a brown head.

Locust Leaf Miner (See Key, 14)
(Xenochalepus dorsalis)

Host. — Black locust.

Injury. — Blisterlike spots or brown patches and holes on the leaves. The early stage larvae feed as a colony on a single mine; but

FIGURE 37. — Leaves mined by the elm leaf miner. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

later they mine individually, and there will be several mines in a single leaf (fig. 38). There are two generations; and when populations are high, there will be premature leaf fall, allowing for refoliation. Although the early feeding is more serious, that on the second crop of leaves is also important, as the stored food necessary for the next season's growth may be seriously depleted. In heavy infestations, large areas are brown as if burned. Although the feeding injury by the larvae is the more important, some damage is caused by the beetles as they skeletonize the lower surface of the leaves or chew small holes in them.

Description. — The adults are small flat beetles, about one-fourth inch long and orange red in general color; heads, antennae, and legs are black. The black inner edge of each wing cover forms a dorsal stripe when the wings are closed. The full-grown larvae are yellowish white with black heads and are about one-fourth inch long.

FIGURE 38. — Locust leaf (much enlarged) mined by the locust leaf miner. (Photo courtesy of Pennsylvania State University.)

Basswood Leaf Miner (See Key, 14)
(Baliosus ruber)

Hosts. — Basswood and oak.

Injury. — The adults skeletonize the leaves, usually the upper surface, in late May and early June. When abundant, complete browning may result. The young adults also skeletonize the leaves in the fall. The larvae mine the leaves in June and July; often several may be in one common mine (fig. 39). This is the more conspicuous evidence of injury, and it is usually more serious than that caused by the adults. Following heavy feeding for 2 or 3 years, the tree crowns become thin and dead branches are common, but few trees die.

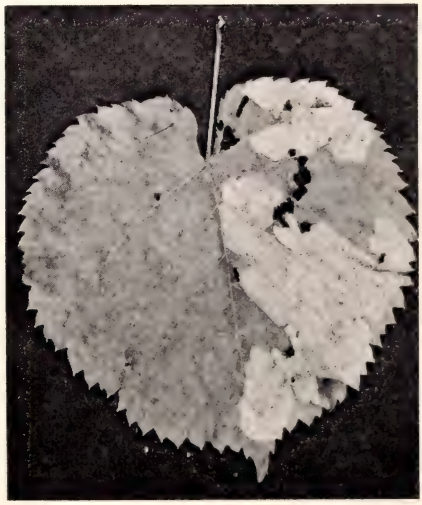

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FIGURE 39. — A leaf mined by the basswood leaf miner.

Description. — The adults are broad, wedge-shaped, reddish-yellow

beetles about one-fourth inch long. The full-grown larvae are also about one-fourth inch long; their general body color is white and the head and thorax are brownish red.

Cottonwood Leaf Beetle (See Key, 14)

(Chrysomela scripta)

Hosts. — Aspens and willows.

Injury. — The adults appear early in the spring and chew holes in the developing leaves and also chew the tender bark at the branch tips. The gregarious larvae skeletonize the lower leaf surface (fig. 40). When the insects are abundant, young saplings may be completely defoliated. Depending on weather conditions, there will be two or three generations annually.

Description. — The hard-shelled beetles, which are about one-third inch long, have a black head and thorax. The wingcovers are generally yellow with black interrupted stripes, although they may be almost black. The young larvae are black and when full-grown are a dirty yellow and about three-eighths inch long.

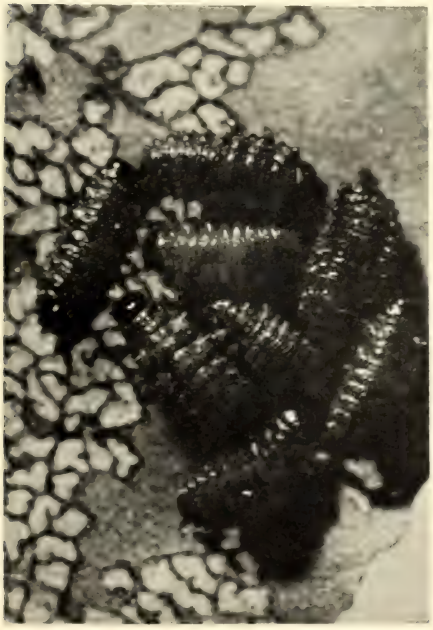

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FIGURE 40. — Cluster of leaf beetle larvae feeding on an aspen leaf.

Cottonwood Leaf-Mining Beetle (See Key, 14)

(Zeugophora scutellaris)

Hosts. — Aspens, chiefly cottonwood.

Injury. — Often abundant in riverbottoms in shelterbelt areas, the adults skeletonize the lower surface of the young leaves in May. The larvae feed just below the upper leaf surface in June; they are solitary feeders, but there may be several separated mines in a leaf. The lower layers of spongy leaf tissue turn black, and heavy feeding makes this appear as large, black blisters. When the insects are abundant, complete defoliation may occur over relatively large areas. The damage appears similar to that caused by cottonwood leaf beetles.

Description. — The beetles are about one-eighth inch long; the wingcovers and the abdomen are black and the remainder of the body is yellow. The yellowish-green larvae are flat, and they have characteristic black markings on the dorsal and ventral surfaces. When full grown, they are about three-sixteenths inch long.

Elm Leaf Beetle (See Key, 14)

(Galerucella luteola)

Host. — Elm.

Injury. — Damage in forested areas is not usually serious; shade and ornamental trees may be repeatedly defoliated, making them subject to attack by bark beetles, borers, and diseases. The adults eat holes in the leaves; but by far the more serious damage is the skeletonization of the foliage by the

FIGURE 41 — Elm leaf beetle larvae skeletonizing elm leaves. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

larvae (fig. 41), causing the leaves to dry up and fall prematurely. Although there are two generations in the southern part of the Lake States, the first one causes the major portion of the damage.

Description. — The adults are about one-fourth inch long, yellowish green to olive green with a black stripe along the outer margin of the wing covers. The early stage larvae appear to be nearly black; when full grown, they are about one-half inch long and are dull yellow with two black dorsal stripes.

GALL MAKERS

Galls are formed on the foliage or woody portions of a tree as a result of the feeding activities of certain aphids, mites, gall wasps, and wood borers. The leaves in particular are subject to attack by a relatively large number of insects and mites which cause the development of leaf galls. Larvae of certain wood-boring beetles also cause galls, but the main damage is from their tunneling and subsequent breakage of twigs, branches, and stems of sapling trees.

Galls formed by these pests — especially leaf galls — are frequently very striking. A specific pest can often be identified by the bizarre shape and color of the gall which develops around it. In spite of appearances, little real damage is caused by these galls in most cases. Affected leaves are often able to carry out photosynthesis in a near-normal manner. In contrast, some of the less striking twig and branch galls can kill a significant portion of the crown, and a general decline of tree vigor follows.

Psyllids

Hackberry Nipple Gall (See Key, 20)
(Pachypsylla celtidismamma)

Host. — Hackberry.

Injury. — Conspicuous galls on the undersurface of the leaves. When abundant, they seriously deform the leaves and may cause early leaf fall.

Description. — The nipplelike gall is light green and about one-sixth inch in diameter (fig. 42). It forms on the under leaf surface and causes depressions on the upper leaf surface. The nymphs, which inhabit the galls, are pale yellowish green with red eyes. The adults are small, jumping plant lice.

FIGURE 42. — The hackberry nipple gall. (Photo courtesy Illinois Natural History Survey.)

Aphids

Poplar Vagabond Aphid
(See Key, 22)
(Mordwilkoja vagabunda)

Hosts. — Quaking aspen and cottonwood.

Injury. — Peculiarly curled and twisted masses of foliage up to 2 inches in diameter at the tips of the twigs (fig. 43). Early in the summer the injury appears as shiny-green, thin-skinned hollow galls, As they mature they change color through dark brown to black. They hang on the twigs during the winter, causing an unsightly appearance.

F-506747
FIGURE 43. — A vagabond aphid gall on quaking aspen.

Description. — Each gall contains a single wingless aphid, the parent of a generation which feeds on an unknown alternate host. The aphids leave the galls in midsummer, but return to them in the fall to hibernate. This habit results in reinfestation of some trees year after year, whereas trees nearby seem to be immune.

Poplar Petiole Gall Aphids
(See Key, 23)
(Pemphigus populicaulis)
(Pemphigus populi-globuli)
(Pemphigus populi-transversus)

Hosts. — Aspens.

Injury. — The first two species form galls at the junction of the petioles and the leaves; the third species forms them near the middle of the petioles. They are of little importance in the forest, but may damage some shelterbelt or shade trees. Sometimes attacked leaves drop prematurely and the crowns of heavily infested trees may appear to be thin.

Description. — The galls look somewhat like those caused by the aspen gall moth (discussed below), but they are semiglobular and sometimes cone-shaped. There is a mouthlike orifice and the interior of each gall is crowded with small plant lice (aphids) feeding on the succulent walls. The mealy white powder and globules of honey dew distinguish these galls from those of the aspen gall moth.

Moths

Aspen Petiole Gall Moth
(See Key, 23)
(Ectoedemia populella)

Hosts. — Aspens.

Injury. — Formation of galls on the petioles at the junction with the leaves (fig. 44). When heavy attacks occur, early leaf fall may be an important problem, particularly in shelterbelt plantings or on shade and ornamental trees.

Description. — The globular galls, usually the same color as the peti-

FIGURE 44. — Petiole galls caused by the aspen petiole gall moth. (Photo courtesy U.S. Northeastern Forest Experiment Station.)

oles and about the size of a large pea, measure up to three-eighths inch in diameter. They are caused by small, slightly flattened caterpillars. So far as is known there is one generation annually.

Mites

Ash Flower-Gall Mite (See Key, 21)

(Eriophyes fraxiniflora)

Hosts. — White ash.

Injury. — Masses of irregular fringed galls, often 2 inches or more in diameter at the tips of the flower-bearing twigs. These masses are formed by numerous lobed galls which may be as much as a half-inch in diameter. Trees are not killed but their unsightly appearance makes this insect an important shade and ornamental tree pest.

Description. — The galls result from the feeding activity of small mites in the staminate flower clusters. When first formed, the galls are greenish; by midsummer they turn dark brown or black and remain on the twigs over the winter in a dried-up condition (fig. 45).

F-506743

FIGURE 45. — An old, dry ash flower-gall at the lower right. At the top are newly infested staminate flowers.

Maple Bladder-Gall Mite (See Key, 20)

(Vasates quadripedes)

Hosts. — Red maple and silver maple.

Injury. — When very numerous, these galls may cover the leaves almost completely. The leaves will be disfigured and tend to turn color early; the following season the foliage may be pale and thin, giving the tree an unthrifty appearance. The injury is of importance on shade and ornamental trees, but is of no economic consequence in the forest.

Description. — The small, reddish, bladderlike galls, which are very noticeable early in the summer, are caused by a small blister-mite (fig. 46). The galls are green in the spring, later changing through dull purple to red. They are about one-eighth inch in diameter, and at the end of the summer they dry up and are black.

F-506694

FIGURE 46. — The bladderlike galls on red maple made by the maple bladder-gall mite.

Poplar-Gall Saperdas (See Key, 10)
(Saperda moesta)
(Saperda concolor)

Hosts. — Aspens and willow.

Injury. — Swelling or gall formation in small living twigs (usually less than three-fourths inch in diameter) on trees of all sizes and in the stems of suckers and seedlings. The first evidence of attack is the egg-laying incisions — those of *moesta* are horseshoe shaped and only one egg is laid in each, whereas those of *concolor* are longtitudinal (fig. 47) and one egg is laid at each end. Two to five incisions are made around a twig, and callous tissue over these incisions causes a globose gall. The larvae mine around the twig and then bore into the wood, where they make galleries about 1 inch long and parallel to the axis of the twig. Usually the infested twigs are not killed. Numerous galls on a single stem or branch cause a cessation of growth and susceptibility to wind breakage. Occasionally a gallery may become infected by *Hypoxylon* canker, resulting in death of the twig.

FIGURE 47. — The typical swelling in an aspen sucker caused by the poplar-gall saperda *(Saperda moesta)*. Note the horseshoe-shaped egg scar. (Photo courtesy of the University of Michigan.)

Description. — The adults are small beetles, about one-half inch long. The *moesta* adults are gray to black in color, while those of *concolor* are a uniform light gray. The mature larvae, about three-fourths of an inch long, are creamy-white and legless.

Gall-Making Maple Borer (See Key, 9)
(Xylotrechus aceris)

Hosts. — The maples, with red maple favored.

Injury. — Attacks originate at the base of a dead twig or in a wound. As a larva develops it tunnels in the sapwood and then into the heartwood, often destroying the central portion of the trunk. A swelling or gall is formed, which results in a deformity and breakage or means of entrance for secondary insects or fungi (fig. 48).

Description. — The adult is a moderately robust beetle about one-half inch long; the thorax is black with four yellow spots, and the wingcovers are light brown with indistinct whitish markings. The full-grown larva is slightly longer than the adult, cream colored, and legless.

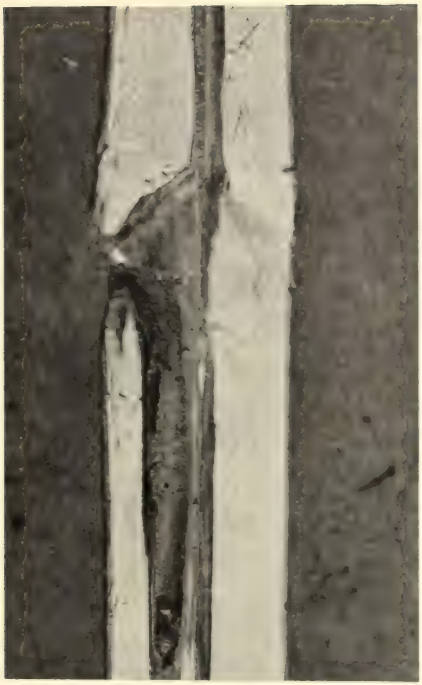

FIGURE 48. — Attack by the gall-making maple borer. (Photo by D. C. Anderson, courtesy Canada Department of Forestry.)

Poplar-and-Willow Borer
(See Key, 10)
(Sternochetus lapathi)

Hosts. — Aspens and willows.

Injury. — Young trees and nursery stock are most susceptible to attack, which usually occurs at the base of the trees. The young larvae feed in the outer sapwood layers and later bore toward the center of the stem. When the attack is heavy, the affected area will be honeycombed with galleries and breakage will occur. Broken places in the bark, through which the larvae push their frass, and knotty gall-like swellings are characteristic evidence of attack (fig. 49).

FIGURE 49. — The knotty, gall-like swellings caused by the poplar-and-willow borer. (Photo courtesy of the New York State University College of Forestry at Syracuse University.)

Description. — The adults are weevils, about three-eighths inch long, dark brown to nearly black in general color, and mottled with light brown and gray scales. The larvae are white, footless grubs and, when full grown are about one-half inch long.

Gall Wasps

Gouty Oak Gall (See Key, 7)
(Callirhytis punctata)
Horned Oak Gall (See Key, 7)
(Callirhytis cornigera)

Hosts. — Northern red oak and black oak.

Injury. — Death of twigs and even good-sized branches, due to development of rough, woody swellings. Often several galls are fused together into a continuous formation of abnormal woody tissue (fig. 50, left). This type of damage to ornamental trees is, at times, of considerable importance.

Description. — Swellings up to 1½ inches in diameter, containing numerous small larvae, which de-

FIGURE 50. — *Left,* gouty oak galls. (Photo courtesy Illinois Natural History Survey.) *Right,* a horned oak gall in cross-section to show holes at the base of the horns. (Photo courtesy U.S. Northeastern Forest Experiment Station.)

velop into gall wasps. The insects hibernate in the galls, emerge in the spring, and lay eggs in the developing buds. The galls of the horned oak galls have conelike projections which are hollow at the base (fig. 50, right).

Ribbed Oak Gall (See Key, 8)
(Andricus gemmarius)

Hosts. — The red oak.

Injury. — Death of twigs and branches when they are heavily infested. Occasionally young trees will be killed.

Description. — The galls are somewhat conical, strongly ribbed, and about one-quarter inch long. They form crowded masses in longitudinal cracks of the bark (fig. 51). In the summer the galls discharge a sweet secretion which attracts large numbers of bees and flies.

Oak Fig Gall (See Key, 8 and 18)
(Biorhiza forticornis)

Hosts. — White oaks.

Injury. — Numerous galls on the twigs and leaves. There is little damage to the leaves, but heavily infested twigs may be killed.

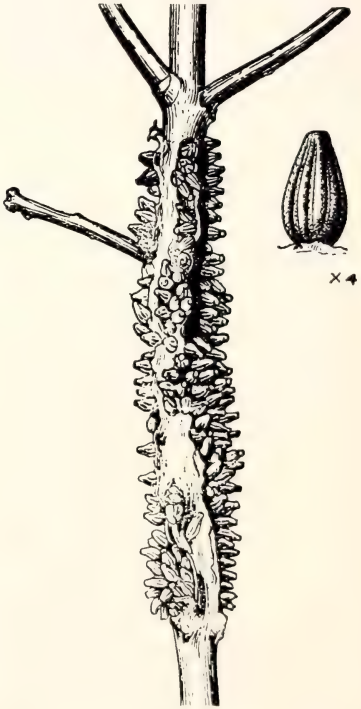

FIGURE 51. — Oak twig infested by the ribbed oak gall. (Drawing by E. P. Felt, courtesy of the U.S. Northeastern Forest Experiment Station.)

FIGURE 52. — The oak fig gall. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

Description. — Early in the season these galls are reddish, bladder-like growths, each gall containing the larva of a small gall wasp. They measure up to one-half inch in diameter, and when they develop in a dense cluster around a twig they may be several inches long, in an irregular mass looking not unlike pressed figs (fig. 52).

Oak Flake Gall (See Key, 18)
(Neuroterus floccosus)

Hosts. — White oaks.

Injury. — Large numbers of galls, mostly singly along or near the veins on the undersurface of the terminal leaves. Heavily infested leaves curl and cause an unsightly appearance to shade and ornamental trees. Occasionally the galls may be found in flower clusters. The leaf curl becomes noticeable in July.

Description. — Small, hemispherical galls smooth at the leaf surface and thickly covered with white wooly hairs below (fig. 53.) The adults are small gall wasps.

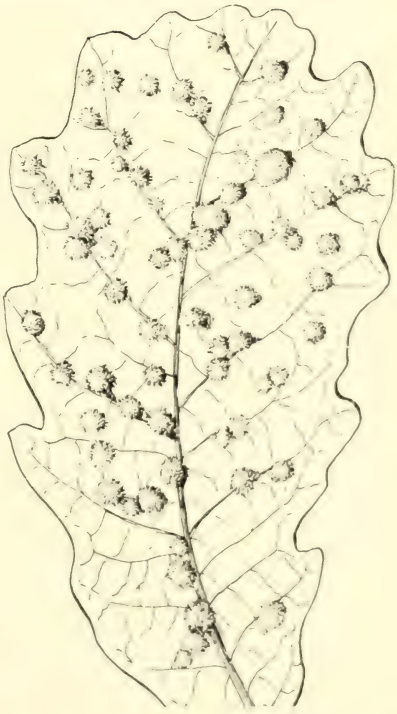

FIGURE 53. — The oak flake gall. (Courtesy American Museum Natural History.)

FIGURE 54. — The large oak-apple gall. (Photo courtesy Illinois Natural History Survey.)

Large Oak-Apple Gall (See Key, 17)
(Amphibolips confluentus)

Hosts. — Principally red, black, and scarlet oaks.

Injury. — The injury is of little economic consequence; aesthetically, it may be important in that a large number of galls, especially when they are mature, gives the tree an unsightly appearance.

Description. — The mature insects are small, gall wasps which appear early in the spring; the eggs are laid in the tissues of the leaves or the petioles. The globose galls are ½ to 2 inches in diameter and are conspicuous. As they develop, they change from green to brown (fig. 54). One larval cell is in the center of the gall, which is filled with a spongy mass of fibers.

SUCKING INSECTS

Aphids and scales are common pests in open-growing hardwood stands and ornamental trees. Some species, when abundant, can kill branches or weaken a tree so that it is less resistant to drought conditions or to successful attack by wood borers or fungi. The lace bugs and leafhoppers and the like are other forms of sucking insects which cause foliar damage to numerous hardwood species. In some cases they may act as vectors for disease organisms.

Diagnosis of tree damage by sucking insects generally depends upon identification of the pest itself. Though the individual insects are small, they are usually present in great numbers, covering leaves, twigs, or whole stems. Frequently a waxy or wool-like substance covers the pests and is useful in identification. In scales, the characteristic color and shape of the "shells," which usually persist even on dead individuals, will aid in identification. Aphids and other pests frequently cause an overgrowth of host tissue (gall). These are treated in a separate section, headed "Gall Makers."

The reaction of the tree to damage by sucking insects is usually characterized by wilted leaves, dying branches, reduced growth, etc. If these symptoms are observed but the pests cannot be found on the trees, they may still not be ruled out as the causal agents. Many species of aphids spend only part of their lives on the primary (tree) host and the rest on particular alternate hosts — usually specific shrubs and herbs.

Aphids

Woolly Elm Aphid (See Key, 24)
(Eriosoma americanum)
Woolly Apple Aphid (See Key, 24)
(Eriosoma lanigerum)
Woolly Elm Bark Aphid
(See Key, 24)
(Eriosoma rileyi)

Hosts. — Elms.

Injury. — Leaf curling by the first two species from early spring to midsummer. When growth begins in the spring the aphids that have hatched from the overwintered eggs begin to feed on the developing elm foliage, causing the affected leaves to curl (fig. 55). The resulting generations of aphids are produced in these leaves. Although most of the leaf curl occurs in the spring, it may also be noticeable during the summer due to activity of the later generations. The woolly masses of the bark aphid are found on the branches, and heavy attacks kill small branches.

FIGURE 55. — Leaf curl caused by the woolly elm aphid. (Photo courtesy Pennsylvania State University.)

Description. —The two leaf aphids (woolly elm and woolly apple) look much alike; they are purple and are clothed with a white woolly waxy covering. There are several generations annually, and in many cases species can be determined by the presence of an alternate host on which at least one generation develops. Serviceberry is the alternate host for *americanum*, while apple is the alternate host for *lanigerum*. American elm is the only known host for *americanum*; but most of the elms are attacked by *lanigerum*. The closely related woolly elm bark aphid is brown bodied and covered with a white woolly wax. The entire development is spent on elm.

Scales

European Elm Scale (See Key, 31)
(Gossyparia spuria)

Hosts. — Elms, chiefly on shade and ornamental trees.

Injury. — Heavy nymph populations result in foliage yellowing, and honeydew excreted by the female scales causes formation of a sooty mold. Premature leaf drop and death of twigs follow. Young trees may be killed, and older trees may be weakened sufficiently to permit further decadence and death by drought and bark beetle and fungus attacks.

Description. — The reddish-brown oval-shaped adult female has a conspicuous, waxy fringe along the body margin (fig. 56). The young nymphs (crawlers) are bright yellow and very small. They feed and develop along the main leaf veins; in the fall they migrate to the branches and hibernate in bark crevices.

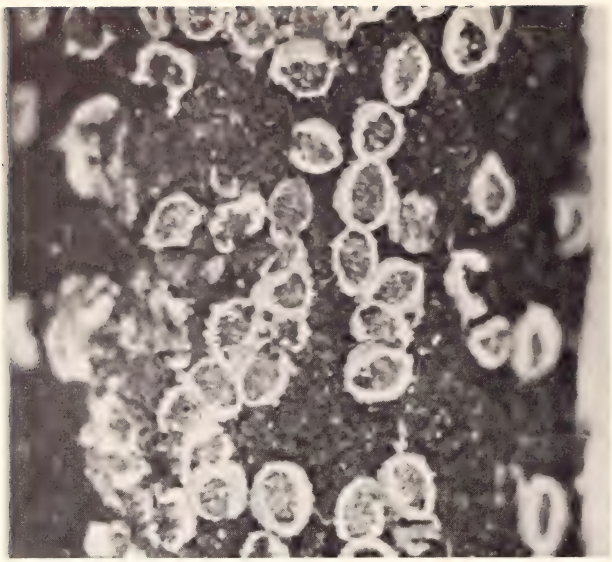

FIGURE 56. — Female European elm scales; the waxy fringe is conspicuous. (Photo courtesy Illinois Natural History Survey.)

Elm Scurfy Scale (See Key, 31)
(Chionaspis americana)

Hosts. — Elm and hackberry.

Injury. — Death of twigs, branches, and even small trees when there is an abundance of these scales. Large trees may be sufficiently weakened by heavy attacks to permit successful attack by wood-boring insects.

Description. — The mature females are shaped like oystershells and are about one-eighth inch long. They are dirty-white in general color, and frequently the front part is grayish (fig. 57). When a scale is removed a whitish scar remains on the bark. The male scales are very small, less than one twenty-fifth inch long; they are found on the bark and on the undersurface of the leaves. The closely related scurfy scale, *Chionaspis furfura,* is also found on elm, ash, aspen, maple, and other hardwood hosts. The females are pear-shaped, are slightly smaller than those of *C. americana,* and somewhat darker.

Maple Leaf Scale (See Key, 30)
(Pulvinaria acericola)
Cottony Maple Scale (See Key, 30)
(Pulvinaria innumerabilis)

Hosts. — Silver maple is the preferred host, but other maples and even other hardwood species may be attacked.

Injury. — The nymphs (crawlers) of these two species of sucking insects feed on the lower surface of the leaves and on the twigs. Large white cottony masses, popcorn-like in appearance, may be found in the spring on the twigs and branches (fig. 58). The foliage is covered with honeydew and a sooty fungus. These attacks cause yellowing and early foliage drop, and death of the twigs. Heavy populations may kill larger branches or even an entire tree.

Description. — The adult females of the cottony maple scale are elongate-oval, brown soft scales nearly three-tenths inch in length and slightly less in width, with a conspicuous elongate white egg sac.

FIGURE 57. — A heavy infestation of the scurfy scale, which is similar to the elm scurfy scale. (Photo courtesy of the Illinois Natural History Survey.)

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FIGURE 58. — Hibernating cottony maple scales on silver maple twigs.

Those of the maple leaf scale are dark purple with a brown stripe down the middle. They are about one-quarter inch long and also bear the white egg sac. The crawlers, which are found principally along the veins on the lower leaf surface, are small, oval, and brown. The cottony maple scale hibernates as an adult female on the twigs, while the maple leaf scale hibernates as a partially developed nymph on the twigs. The egg masses are produced in the spring.

Oystershell Scale (See Key, 32)
(Lepidosaphes ulmi)

Hosts. — Ash, birch, aspen, maple, elm, basswood, and willow. More than 125 plant species are subject to attack.

Injury. — Twigs and small branches may be encrusted with these scales; the first evidence of attack, however, is early yellowing of foliage. Heavy feeding will retard growth and often kill twigs and even large branches. Ash reproduction may be seriously affected. The spread from tree to tree is slow because it must be done by the crawlers, which are first-instar nymphs.

Description. — The mature female scales look like miniature oystershells, hence the name (fig. 59). They are about one-eighth inch long, broad and rounded at the rear, and narrow in front. The color varies from dark brown in summer and fall to gray in winter. The males are smaller but are very rare. The pale yellow female crawlers hatch from the overwintered eggs in late May and early June. They feed on the plant tissues and produce a mass of waxy threads. By early August these females have matured and have laid their eggs under the hard brown scale covers.

FIGURE 59. — Oystershell scale. (Photo courtesy of Pennsylvania State University.)

San Jose Scale (See Key, 36)
(Aspidiotus perniciosus)
Putnam Scale (See Key, 36)
(Aspidiotus ancylus)

Hosts. — Ash, basswood, birch, and elm.

Injury. — Removal of sap by these sucking insects retards growth and kills branches. Heavily infested trees, with dead and dying branches, look weak and sickly. There may be two generations, but cold weather and natural enemies kill many scales and generally prevent heavy damage.

Description. — The mature female scales are round, with a dark central nipple (fig. 60). They are gray and about one-sixteenth inch in diameter. The tiny, young crawlers are yellowish. They soon begin forming

FIGURE 60. — The San Jose scale. The large forms are mature females; the small ones are the young scales which have developed from the new generation. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

a whitish scale covering, which gradually darkens and becomes dark gray or black.

The closely related Putnam scale is about the same size and shape as the San Jose scale, but the females are a little darker and the nipple is off center and a brick red. Favored hosts are basswood and soft maple.

Terrapin Scale (See Key, 35)
(Lecanium nigrofasciatum)

European Fruit Lecanium (See Key, 35)
(Lecanium corni)

Hosts. — Maple, elm, hickory, walnut, butternut, and sycamore.

Injury. — Heavy scale populations secrete tremendous amounts of honeydew during the early summer, and a sooty mold develops. The trees lose vigor and appear unhealthy. Small branches may be killed.

Description. — Following hibernation, the female terrapin scales mature in the spring. They are about one-eighth inch long, and somewhat oval and very convex in shape. Their general color is reddish brown (fig. 61), and numerous black bands radiate from the center to the edges. They are often covered with a whitish powdery substance. The tiny newly hatched young are yellowish and found along the leaf veins. As they develop, they migrate to the bark of the twigs and small branches. There is one generation annually in the northern states. The closely related European fruit lecanium, or brown elm scale, also infests a wide range of forest tree hosts. The mature females are smaller and darker than those of the terrapin scale, and the black bands are absent. The life history and injury are similar.

Golden Oak Scale (See Key, 33)
(Asterolecanium variolosum)

Hosts. — Oaks.

Injury. — Gall-like pits in the bark wherever these scales have settled to feed. Reproduction and sprout growth are most seriously affected, and heavy infestations will cause death. Branches of large trees

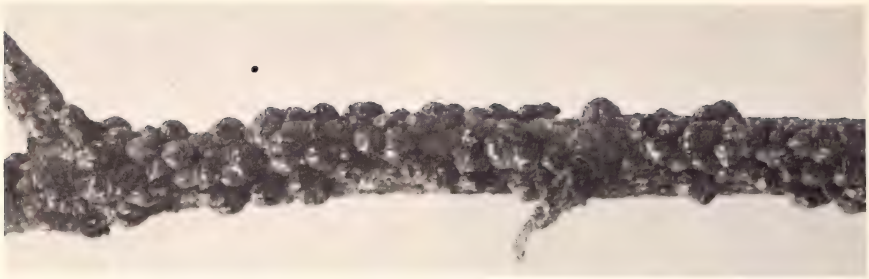

FIGURE 61. — A small branch heavily infested by the terrapin scale. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

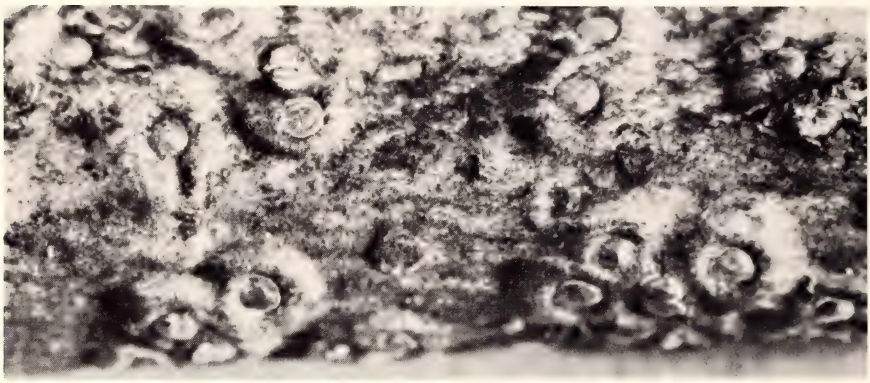

FIGURE 62. — The golden oak scale. Note the depressions on the bark. (Photo courtesy of the Bartlett Tree Expert Company.)

may be killed and, when heavy attacks are followed by drought, mature trees may be severely weakened or die.

Description. — The female scales are circular, slightly convex, about one-sixteenth inch in diameter (fig. 62), and greenish-gold in general color. These scales can be readily recognized by the pitlike depressions in the bark.

Lace Bugs

Elm Lace Bug (See Key, 24)
(Corythucha ulmi)
Sycamore Lace Bug (See Key, 24)
(Corythucha ciliata)

Hosts. — American elm in natural stands and in shelterbelts as well as shade trees. Siberian elm in shelterbelts.

Injury. — Feeding by developing nymphs. The undersurface of leaves is speckled with eggs, excrement, and cast nymphal skins (fig. 63), and the surface is discolored. In heavy infestations, trees lose most of their leaves and may be seriously weakened, particularly during a drought period. The closely related sycamore lace bug sometimes causes severe damage to street and shade trees. A species, *C. arcuata,* is a pest

of bur oak in shelterbelts and one, *C. pallipes,* is often abundant on birch in Wisconsin.

Description. — The adults have characteristic lacy wingcovers with prothoracic expansion. The head is covered with a lacelike arching hood. The length, depending on the species, varies from one-eighth to one-quarter inch. The nymphs are dark brown to black, have spiny projections, and increase in length as they develop.

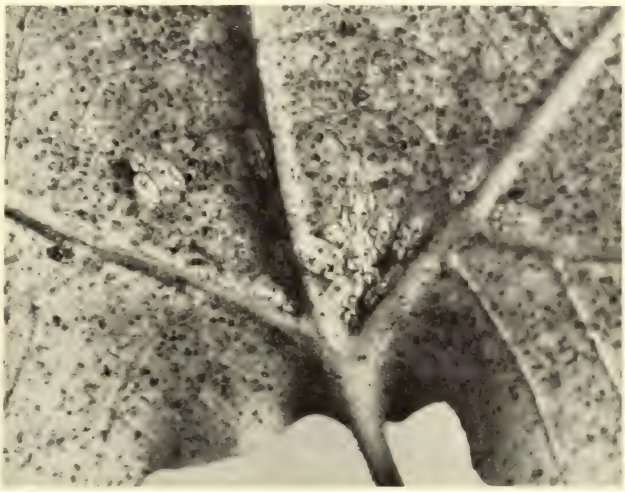

FIGURE 63. — Typical speckling on leaf undersurface caused by lace bug feeding. A cluster of bugs can be seen at the vein junction. (Photo courtesy of The Connecticut Agricultural Experiment Station.)

BUD, TWIG, BRANCH, AND STEM BORERS

The borers are differentiated from the previous groups of insects on the basis of their feeding habits —they feed on the wood rather than on the leaves or plant juices. Also, their feeding does not induce a typical gall formation in the affected tree part.

The larvae (and the adults in a few cases) of a variety of beetles, moths, ants, wasps, and flies attack all parts of hardwood trees from the buds and twigs to the roots. Many of the species may be attracted to weakened trees; their activities may hasten death of the tree and cause lumber degrade. On the other hand, certain species, especially the true wood borers, can successfully attack vigorous trees; extensive larval galleries in the sapwood and heartwood may result in girdling, stem breakage, and lumber degrade. Pith-ray flecks do not seriously affect tree health, but do result in a reduced value of the finished wood because of a spotty discoloration.

The activities of insects belonging to this group are generally not readily apparent. For example, even heavy infestations of certain wood borers may escape notice by those who have day-to-day contact with the affected trees. The most common damage symptom is the death or deformation of the affected tree part. Since the death of, say, a branch is a nonspecific symptom, the cause can be determined only by careful inspection for characteristic egg niches, galleries, exit holes, and the insect specimens themselves.

Some of the primary wood borers can be diagnosed simply on the basis of the tree species affected and condition of the tree. For example, insects tunneling in the stems of apparently healthy aspen are usually larvae of the poplar borer, *Saperda calcarata.*

Buds and Twigs

Maple Bud Borers (See Key, 26)
(Proteoteras spp.)
Boxelder Twig Borer (See Key, 37)
(Proteoteras willingana)

Hosts. — Boxelder in nurseries, windbreaks, and shelterbelts and as ornamentals in the northern Great Plains; sugar maple in the northern Lake States.

Injury. —The boxelder twig borer destroys the dormant buds in the fall as well as in the spring, and tunnels in the current season's shoots (fig. 64). These shoots are killed and terminal growth prevented; forking and occasionally twig breakage result. In heavy infestations many of the twigs on a single tree will be infested and the trees will become bushy. The maple bud borers also destroy the buds in the spring; the resulting forked growth is a serious deformity in reproduction and small sugar maple saplings.

Description. — The adults are small moths with a wingspread of five-eighths inch; they are white to pale brown. The full-grown caterpillars are about one-half inch long, and are whitish yellow with a dark-brown head capsule.

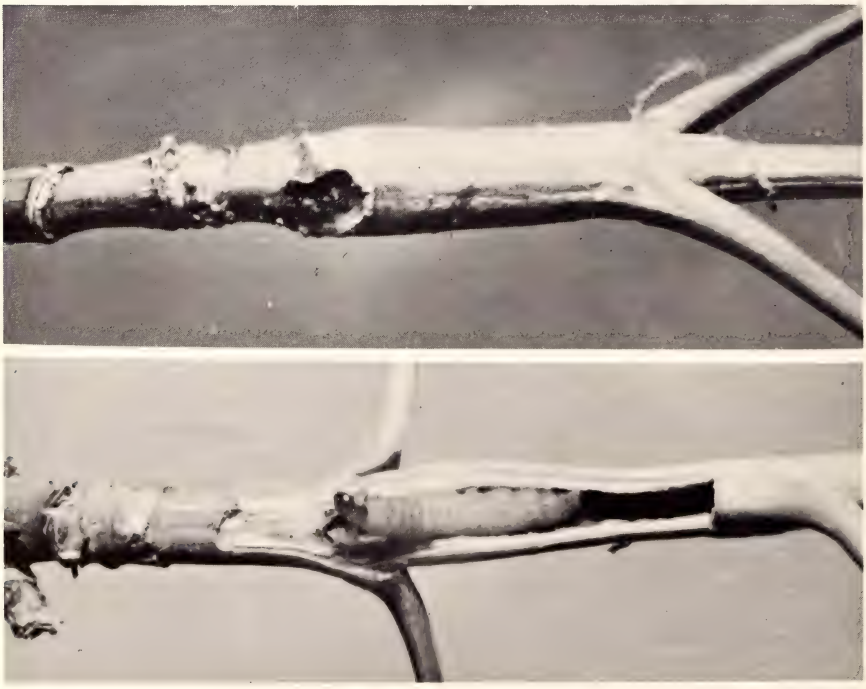

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FIGURE 64. — *Top,* boxelder infested by the boxelder twig borer. *Bottom,* portion of a stem removed to show a borer.

Locust Twig Borer (See Key, 37)
(Ecdytolopha insiticiana)

Hosts. — Black locust.

Injury. — Irregular, elongate swellings in the new growth, 1 to 3 inches long (fig. 65). Old swellings often crack open, and when they are numerous twig growth may be retarded.

Description. — A twig borer, the full-grown caterpillar is one-half to three-quarters inch long. The head is dark brown, and the body reddish to straw yellow, and darker along the dorsal line. The moth is grayish-brown and has a wing expanse of about 1 inch.

FIGURE 65. — The swellings caused by the locust twig borer. (Photo courtesy of Duke University School of Forestry.)

Poplar Twig Borer (See Key, 37)
(Oberea schaumii)

Hosts. — Aspen.

Injury. — Longitudinal tunnels in the center of living twigs, usually less than three-fourths inch in diameter, of saplings, poles, and larger trees, and in stems and branches of suckers and seedlings. "Push-out"

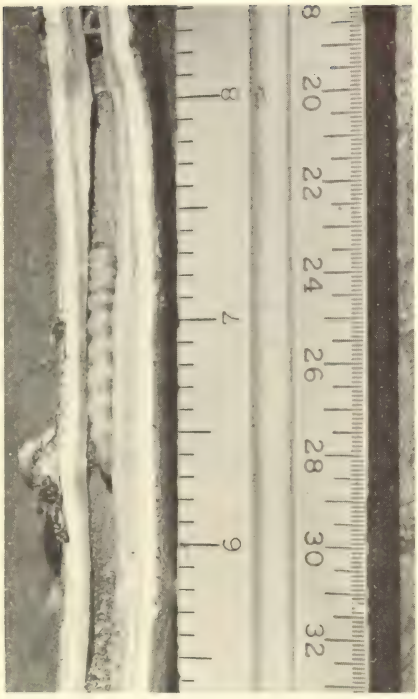

FIGURE 66. — A mature poplar twig borer in the center of an aspen twig. (Photo courtesy of the University of Michigan.)

holes are made, through which borings and frass are expelled, thereby keeping the tunnels clean (fig. 66). Black, necrotic areas develop around these holes. Generally the twigs are not sufficiently weakened to allow wind breakage.

Description. — The adults are slender beetles, about five-eighths inch long, with yellowish or black wing covers and four round black spots on the thorax. The full-grown larvae are about three-fourths inch long, yellow, and legless.

Twig Pruner (See Key, 37)
(Elaphidion villosum)

Hosts. — Many hardwoods, chiefly oak, maple, and hickory.

Injury. — Pruning of living branches. Attack begins with egg-

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FIGURE 67. — Oak twigs pruned by the twig pruner.

laying in the axil of a leaf near the tip of a twig; twig mining by the early stage larva follows. As the larva develops it tunnels down the stem, and late in the summer it makes concentric cuts outward from the center except for the bark. It retreats into the severed portion to hibernate, appearing as a beetle in the spring. The severed branches, sometimes 2 inches in diameter, break off in the wind (fig. 67). This is not an important forest insect, but heavily infested shade trees are unsightly.

Description. — The adult is a brownish beetle, about three-quarters inch long, with a pair of short spines at the tip of each wingcover. The full-grown shiny-white larva is slender and slightly longer than the adult. The closely related spined bark borer (*Elaphidion mucronatum*) is similar in general appearance, but it is a little larger and has stronger spines. The eggs are laid on dead twigs, and the larva feeds beneath the bark during the first season, exuding granular frass. The second season it tunnels in the sapwood. Prior to pupation it severs the branch in the same way as the twig pruner.

Birch and Beech Girdler (See Key, 37)

(Xylotrechus quadrimaculatus)

Hosts. — Birch, beech, and maple.

Injury. — Somewhat similar to the damage by the twig pruners in that branches up to 2 inches in diameter are severed or girdled (fig. 68). The cutting, however, is from the outside to the center, and a few strands of wood between the concentric cuts remain. Hibernation occurs in the severed portion, and development is completed in 1 year.

Description. — The adult is a moderately robust beetle, about five-eighths inch long; the thorax is black, marked with four yellow spots, and the wingcovers are pale brown with faint white markings. The larva is rather robust, cream colored, and somewhat longer than the adult when full grown.

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FIGURE 68. — Gallery made by the birch and beech girdler.

Larger Branches and Stems

Eastern Ash Bark Beetle
(See Key, 39)
(Leperisinus aculeatus)
White-Banded Ash Bark Beetle
(See Key, 39)
(Leperisinus fasciatus)

Host. — Ash.

Injury. — Girdling caused by tunneling in the inner bark and the surface of the sapwood (fig. 69). Attacks are confined to trees that have been weakened by fire, disease, or mechanical injury — thereby hastening death of the affected part or the entire tree.

Description. — The egg tunnels are forked and across the grain of the wood. The adults of the eastern ash bark beetle are rather stout, dark brown with light tan and gray scales, and a little less than one-eighth inch long. Those of the white-banded ash bark beetle are slightly smaller and are black with white markings. The larvae of both species are white, footless, and, when full grown, slightly longer than the adults.

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FIGURE 69. A branch with the bark removed to show ash bark beetle tunnels. The horizontal ones are egg tunnels; the vertical ones, larval tunnels.

Cambium Miner (See Key, 40)
(Phytobia pruinosa)

Hosts. —Birch, cherry, and maple.

Injury. — Larvae cause defect in lumber, known in the industry as pith-ray fleck. Attack usually begins in suppressed twigs in the spring and progresses down the stem between the surface of the cambium and the inner bark to the base of the tree and even into the roots. The full-grown larvae bore through the bark at the ground level early in the summer and pupate in the soil, passing the winter there. Trees are not killed, and the infestation cannot be detected unless the bark is removed (fig. 70, left). Each year's attack, however, will be evident in a cross-section of a log (fig. 70, right). A disintegration of the woody tissue may result, due to the pith flecks; and heavily infested logs may not be suitable for high-grade veneers or cabinet stock.

Description. — The adults are small flies with membranous wings. The small maggotlike larvae are white and very slender.

Bronze Birch Borer (See Key, 40)
(Agrilus anxius)
Bronze Poplar Borer (See Key, 40)
(Agrilus liragus)
Two-Lined Chestnut Borer (See Key, 40)
(Agrilus bilineatus)

Hosts. — Birch for the bronze birch borer; aspen for the bronze

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FIGURE 70. — *Left*, the appearance of attack in the cambium by cambium miners; *right*, pith-ray flecks in a cross-section of a log.

poplar borer; and oak for the two-lined chestnut borer.

Injury. — Trees of low vigor or weakened in some manner are especially subject to successful attack. After heavy defoliation or after logging operations, attacks by these insects may hasten death of overmature or defective trees and of young trees suddenly released by the removal of dominant trees. The type of larval gallery for each species is very characteristic. The typical meandering galleries made by the bronze birch borer are shown in figure 71, left; those of the bronze poplar borer are typically compact as shown in figure 71, right. Galleries in oak by the closely related two-lined chestnut borer are of the meandering type. In all three species, attacks usually begin in the crowns and progress downward into the bole, thereby causing death. Vigorous trees, even though weakened by defoliation, disease, drought, etc., may withstand attack, healing over the galleries and killing the larvae. Successful attacks do not weaken the trees structurally.

Description. — The adults of the species on birch and aspen are about half an inch long and olive-bronze in general color. Species determination in the field is difficult and should be restricted to host preference. The adults of the two-lined borer are blackish blue, with golden yellow longitudinal stripes on the prothorax and the wing covers. The larvae of all three species are pearly white, slender, flattened, and about 1 inch long when full grown.

Ash Borer (See Key, 44)
(Podosesia syringae fraxini)

Hosts. — Green, white, red, and European ashes. An important pest in shelterbelts.

Injury. — Tunneling in branches and trunks, young trees being more seriously injured than large trees (fig. 72). The smaller branches break at the point of injury. Attack is usually made evident by the appearance of rough, irregular scarlike swellings on the trunks.

FIGURE 71. — *Left*, the meandering galleries made by the bronze birch borer. *Right*, the compact galleries made by the bronze poplar borer. (Photo courtesy R. F. Anderson, Duke University.)

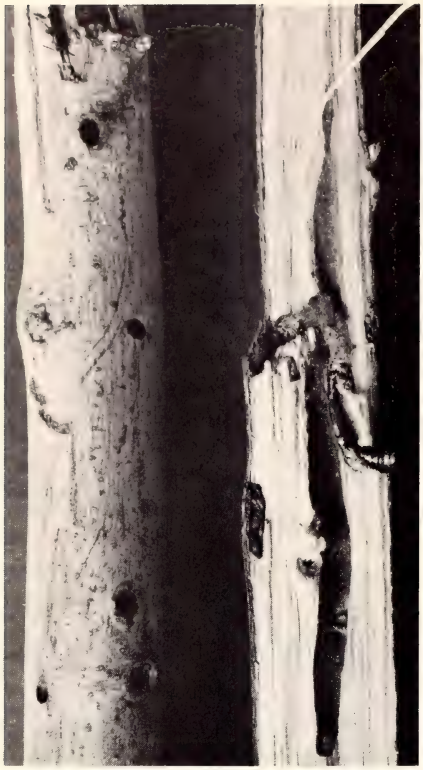

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FIGURE 72. — Tunneling in ash by the ash borer. Note the cast pupal shells.

Description. — A clear-wing moth with a wing expanse of about 1 inch. The forewings are an opaque dark brown with a red cross bar; the hind wings are transparent. The full-grown caterpillar is whitish, with a mahogany colored head, and is about three-fourths inch long.

Maple Callus Borer (See Key, 44)
(Sylvora acerni)

Hosts. — Maples.

Injury. — Attacks usually develop near wounds on the boles of trees. The outer bark will be rough and callused and the sapwood will have scar tissue (fig. 73). Brown, powdery frass will be found in the feeding cavity and on the bark. Cast pupal skins may be noticeable, sticking out of the bark in the callused area. Continued infestation weakens a tree, complete girdling sometimes occurring.

Description. — The adult is a tawny clear-wing moth, with a reddish tuft at the tail. The full-grown caterpillar is about one-half inch long, with a whitish body and a brown head.

FIGURE 73. — The maple callus borer causes the roughened, callused area shown here. (Photo courtesy of New York State University, College of Forestry at Syracuse University.)

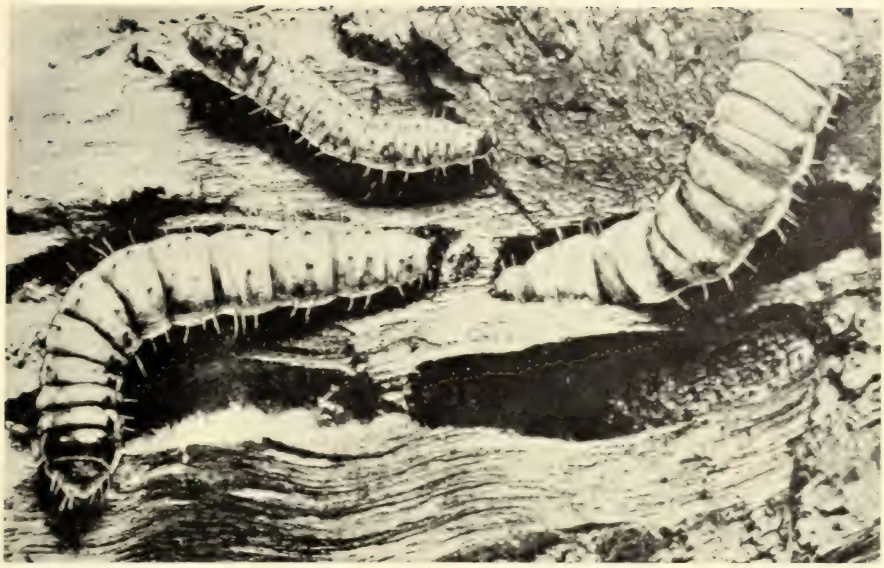

FIGURE 74. — Galleries and larvae of the carpenterworm. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

Carpenterworm (See Key, 43)
(Prionoxystus robiniae)

Hosts. — Oaks, green ash, maple, birch, and aspens.

Injury. — Tunnels in the bark, sapwood, and heartwood of living trees, with associated stain and wood decay, cause lumber degrade (fig. 74). Oval or irregular scars in the bark are evidence of infestation. Damage in lumber appears as oval, oblong, or irregular holes, ½ to 1½ inches in diameter, surrounded by stained wood often extending as much as 2 feet up and down from the gallery.

Description. — The adult is a grayish, stout-bodied moth, uniformly mottled with gray and brown scales. The full-grown caterpillar is 2 to 3 inches long, and greenish white with a shiny brown head and nearly black mandibles (biting mouthparts). The life cycle in the northern states requires 3 to 4 years.

Oak Timberworm (See Key, 46)
(Arrhenodes minutus)

Hosts. — Oak, beech, and aspen.

Injury. — Cylindrical holes in or near wounds caused by broken branches or by fires, or in recently felled or dying trees. The eggs are deposited singly in these holes in May and June and the larvae bore into the sound wood, extending their galleries in all directions. This may cause a high degree of degrade and make logs unfit for special uses such as tight cooperage or flooring (fig. 75).

Description. — The adults are shiny reddish-brown snout beetles, with the wing covers marked by elongate yellowish spots. The males are about one-half inch long and have a broad flat snout; the females are larger than the males and have a long slender snout used in making the cylindrical holes where the eggs are deposited. The larvae are elongate and cylindrical, and have min-

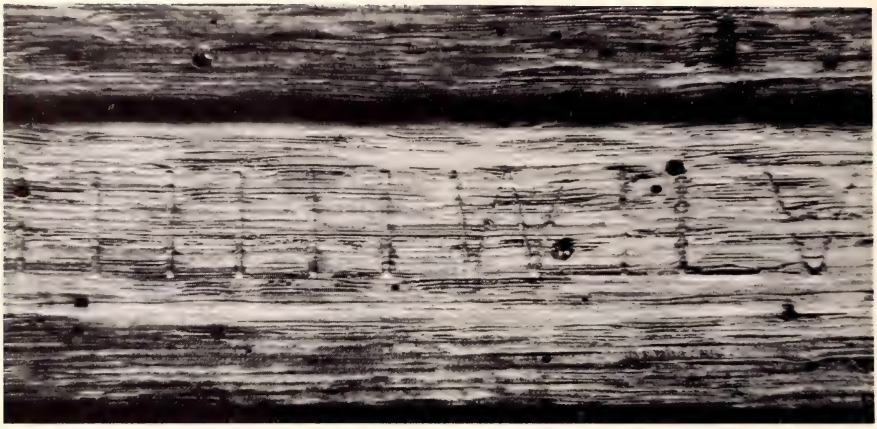

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FIGURE 75. — Oak flooring with pinhole galleries made by the oak timberworm.

ute two-jointed legs. When full grown, they are about three-fourths inch long.

Black Carpenter Ant (See Key, 42)
(Camponotus pennsylvanicus)

Hosts. — Oaks.

Injury. — Galleries in the heartwood of forest trees are generally at the base of decayed or weakened trees or in stumps (fig. 76). Logs, telephone poles, or even the framework of buildings may be damaged. In hardwood trees the galleries are usually separated. Carpenter ants do not eat the wood; rather they are predatory on certain caterpillars and also obtain honeydew from aphids. The wood is excavated in the construction of the ant nests, and little piles of "sawdust" are evidence of attack.

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FIGURE 76. — Cross-section of an oak log showing galleries made by carpenter ants.

FIGURE 77. — *Left*, open, wet wounds caused by sugar-maple borers. (Photo by D. C. Anderson, courtesy Canada Department of Forestry.) *Right*, callous tissue formed over a borer gallery. (Photo courtesy New York State University, College of Forestry at Syracuse University.)

Description. — The black carpenter ant varies in color from dark brown to deep black. The worker ants vary in size, and sometimes exceed a half inch in length. All stages of these insects — eggs, larvae, workers, and a queen — may be found in an active nest.

Sugar-Maple Borer (See Key, 45)
(Glycobius speciosus)

Host. — Sugar maple.

Injury. — This borer is a serious primary enemy; vigorous trees are attacked, especially those in the open or in understocked stands where the trees are in full light. The first symptoms of infestation are moist spots on the bark and frass pushed out through holes at the points of attack. Sometimes the bark cracks at these points, leaving open, wet wounds (fig. 77, left). Two years are necessary to complete development. Not only are parts of the tree killed, but also callous tissue forms over the larval galleries and causes ridges or gall-like swellings on the wood surface (fig. 77, right). Deep galleries, made across the grain of the wood during the second season of larval activity, lead to defect and degrade.

Description. — The adults are robust black beetles, about 1 inch long, with bright yellow markings on the thorax and wingcovers. One of the markings on the wings is a distinct W. The larvae are grayish white and about 2 inches long when full grown. They have three pairs of thoracic legs.

Red-Oak Borer (See Key, 45)
(Romaleum rufulum)

Hosts. — Oaks.

Injury. — Granular frass pushed out from points of attack and wet spots caused by sap leakage from these wounds are conspicuous evidence of early attack. As the larvae develop they bore into the heartwood and, during the second year, make large tunnels. Ants and fungi enter these tunnels and extend the injury, the end result being defects

and serious lumber degrade. Two years are required for development.

Description. — The rather robust beetles, about 1 inch long, are brownish and spotted with yellowish, fine soft hair. Thoracic spines are absent. The shiny white larvae have true legs on the thorax and, when full grown, are slightly longer than the adults.

White-Oak Borer (See Key, 45)
(Goes tigrinus)

Hosts. — White oaks.

Injury. — Galleries in living white oaks similar to those made by the red-oak borer. This species may cause a considerable amount of degrade in tight cooperage stock due to the extensive tunneling in the sound wood. Four or five years are required for full development.

Description. — The beetles are about 1 inch long, dark brown, and densely clothed with white, fine soft hairs. Thoracic spines are present. The larvae are creamy yellow, legless, and, when full grown, slightly longer than the adult.

Poplar Borer (See Key, 45)
(Saperda calcarata)

Hosts. — Aspen.

Injury. — An important primary pest of living trees, the attack is characterized by swollen scars and holes in the trunk and larger branches. "Push-out" holes are made by the feeding larvae through which frass is expelled and sap exudes. The wet areas around these holes are blackened, appearing as if varnished (fig. 78, left). The poplar borers require 3 years to develop, mining deep in the heartwood during this period (fig. 78, right). Heavily infested trees break at points weakened by this tunneling. A serious secondary injury is the development of wood-rotting fungi with resulting additional timber degrade.

Description. — The adult beetles are about 1 inch long, grayish black, and densely clothed with gray and yellow fine soft hairs; they have yellowish stripes on the thorax and orange-yellow markings on the wing

FIGURE 78. — *Left*, external appearance of an aspen attacked by the poplar borer. The black spots are egg-niche scars, and the black streaks are the blackened "varnished" areas caused by sap leakage. *Right*, a section of a stem showing heavy larval attack. (Photos courtesy of the University of Michigan.)

covers. The larvae are creamy white, legless, and about 1¼ inches long when full grown.

Cottonwood Borer (See Key, 45)
(Plectrodera scalator)

Hosts. — Aspens and willows.

Injury. — This insect is injurious to cottonwood and willows in shelterbelts. Small-diameter trees are preferred, and the heaviest attack occurs at the base, abnormal swellings being common. The larvae tunnel under the bark, pushing out large amounts of frass. The trees are girdled and the sap movement is cut off. Breakage often occurs just below the ground line. Some damage is done in midsummer when the beetles feed on the tender bark of small branches. Development to the adult stage takes 2 years.

Description. — The adults are black robust beetles nearly 1½ inches long, and are thickly mottled with white or creamy patches or stripes. There is a small spine on each side of the thorax. The larvae are yellowish white, legless, and about 2 inches long when full grown.

Locust Borer (See Key, 45)
(Megacyllene robiniae)

Host. — Black locust.

Injury. — Slow-growing, overtopped trees on poor sites are most seriously damaged, particularly during drought periods. Thrifty trees are attacked but they can, in most instances, withstand heavy injury. Wet spots on the bark, the result of feeding activity by the early stage borers soon after growth starts in the spring, are evidence of infestation. The borers tunnel into the sapwood, expelling white dust which will be noticeable in bark crevices and at the base of the tree. As they develop they make galleries deep in the wood and lengthwise of the stem (fig. 79, left). There is one generation annually. Repeated attacks over a period of years result in numerous dead and broken limbs and knotty swellings on the trunk. Heavily infested trees are subject to wind breakage (fig. 79, right).

Description. — The adults, about three-fourths inch long, are jet black beetles with numerous bright yellow bands. Four of these extend across

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FIGURE 79. — *Left*, locust borer galleries deep in the wood. *Right*, windbreakage resulting from repeated attacks. Note the knotty swellings.

the thorax, while those on the wingcovers are roughly W-shaped. They may be found in late summer and early fall feeding on the pollen in goldenrod blossoms. The larvae are white, legless, and about 1 inch long when full grown.

Elm Borer (See Key, 45)
(Saperda tridentata)

Hosts. — Elms.

Injury. — Wide, shallow galleries in the inner bark and outer layers of the sapwood filled with fibrous frass. Attack begins in limbs and injured areas on the trunk, and mortality occurs when these galleries make a complete girdle. As the larvae develop, they bore into healthy wood. Usually larger branches die before the tree does. There is one generation annually. Damage in forest areas is not important, but many shade and ornamental trees are heavily damaged. Old or unhealthy trees are vulnerable, especially those previously weakened by repeated defoliation or by the Dutch elm disease.

Description. — The beetles are about a half-inch long. They are densely clothed with grayish fine soft hairs and have three orange oblique crossbars on the wing covers and a narrow orange stripe on the ridges of the thorax and the wing covers. The larvae are similar in general form to other round-headed borers; they are white, legless, and about 1 inch long when full grown.

Banded Ash Borer (See Key, 45)
(Neoclytus capraea)

Red-Headed Ash Borer (See Key, 45)
(Neoclytus acuminatus)

Hosts. — The ashes are the most important hosts, although numerous other tree species, including oak and hickory, are attacked.

Injury. — Dying trees are attacked, but the greatest damage is to logs left in the woods or to unseasoned logs stored in the millyard with the bark adhering. The early stage borers feed for several weeks under the bark, tunneling the surface of the wood (fig. 80, top). In the later stages they make galleries in the sapwood, especially the outer layers, completely honeycombing the wood and packing the galleries with granular frass (fig. 80, bottom). Generally the adults emerge the following spring; but when infested logs are sawed and the lumber allowed to season, development may be retarded and the adults will emerge at irregular intervals over a period of years.

Description. — Banded ash borer adults are dark brown beetles, about one-half inch long, with yellowish-white, irregularly shaped cross bands on the thorax and wingcovers. The red-headed ash borers are reddish-brown slender beetles, varying

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FIGURE 80. — *Top*, tunneling on the wood surface by the red-headed ash borer. (Photo courtesy Illinois Natural History Survey.) *Bottom*, banded ash borer galleries tightly packed with granular frass.

from one-fourth to three-fourths inch in length. They have yellow cross bands on the wingcovers, but none on the thorax. The larvae of the two species are very similar; they are dull white, rather hairy, and have minute thoracic legs. When full grown, they are one-half to three-fourths inch long.

Columbian Timber Beetle (See Key, 47)

(Corthylus columbianus)

Hosts. — Oak, maple, and birch.

Injury. — Tunneling in the sapwood of living trees by adults and larvae; the development of the ambrosial fungus causes a black stain, not only in the tunnels but also below and above (fig. 81, left). The trees are not killed, but the defect is permanent and the timber value is lowered. A closely related species, *punctatissimus,* has been reared from spiral galleries at the base of the stems in healthy silver maples in Minnesota; in 1960 it killed sugar maple and beech reproduction up to a height of 6 feet in Lower Michigan.

Description. — The tunnels are compound, each larva having its special gallery (fig. 81, right). The adults are shiny, dark brown, and about one-eighth inch long. The larvae are white, footless, and, when full grown, a little longer than the adults.

Ambrosia Beetles (See Key, 47)

(Trypodendron sp., *Xyleborus* sp., *Anisandrus* sp.)

Hosts. — Birch, oak, maple, and elm.

Injury. — Tunneling in the sapwood and heartwood by beetles and

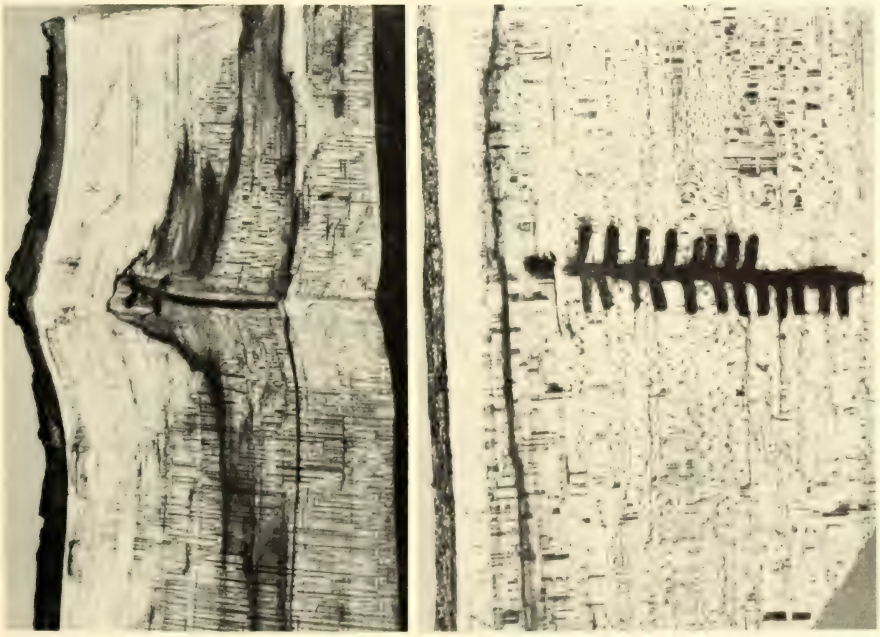

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FIGURE 81. — The black stained tunnels in white oak caused by the Columbian timber beetle. *Left,* slightly reduced. *Right,* slightly enlarged.

larvae, and the development of ambrosial fungus upon which the larvae feed. Although dying or recently cut trees are preferred, the attacks usually result in degrade of lumber and veneer stock.

Description. — The tunnels are compound; each larva has its special gallery branching from the main tunnel as shown in the diagrammatic drawing (fig. 82). They feed on ambrosial fungus brought to them by the adults. The larvae are white, footless, and, when full grown, one-eighth to one-quarter inch long, depending on the species. The adults are dark brown to black and slightly smaller than the full-grown larvae.

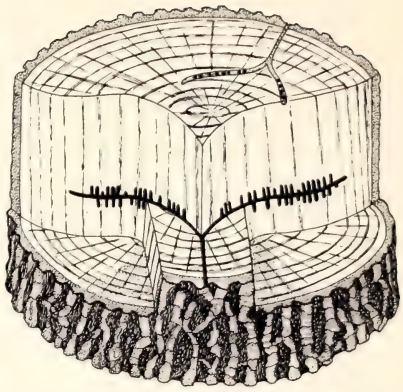

FIGURE 82. — Diagrammatic drawing showing typical ambrosia beetle tunnels. (Photo courtesy New York State University, College of Forestry, at Syracuse University.)

DISEASE VECTORS

A number of insect species are more important in their activities as vectors of tree diseases than they are as primary tree pests. Though these insects could be classified in the preceding groups, they are treated separately here to aid in identification.

Insects may be associated with tree diseases in many different ways. The insects, by their feeding or oviposition activities, may simply provide a means of entrance for the pathogen into the susceptible tissues of the tree. On the other hand, complex biological relationships may exist between the insect and the pathogen, resulting in their mutual benefit. To date, only a relatively few cases of insect-disease complexes are well understood. While these may not now be of especial importance on forest land in the Lake States, they are discussed in order to emphasize their potential danger.

Dutch Elm Disease

Smaller European Elm Bark Beetle
(Scolytus multistriatus)
Native Elm Bark Beetle
(Hylurgopinus rufipes)

Hosts. — All elm species except Siberian elm and Chinese elm.

Injury. — The lethal injury is the development of the Dutch elm disease in healthy trees through the feeding habits of the bark beetles. The beetles carry the fungus on their bodies and introduce the spores, principally at the twig axil, by chewing off the tender bark. Depending on the length of the growing season, there may be one to three generations annually. Of less importance than the smaller European elm bark beetle but still capable of transmitting the disease, is the native elm bark beetle. The presence of the disease can be first suspected when the foliage on a branch or the entire crown suddenly wilts. Confirmation can be obtained by sending insect or injury specimens

to your State Entomologist.

Description. — The adults of the introduced species are about one-eighth inch long, shiny, and dark reddish brown. There is a concavity and a long spine at the rear and lower part of the abdomen. The adults of the native species are also about one-eighth inch long, but are dull brown and do not have a concavity or spine at the rear of the abdomen. The larvae of the two species are very similar — white footless grubs, and, when full grown, about one-eighth inch long. For egg-laying, the beetles prefer recently cut, broken, or dying material. The egg galleries of the European species are usually straight and follow the grain of the wood; those of the native species usually consist of two branches and cross the grain.

Oak Wilt

Smaller Oak Bark Beetle
(Pseudopityophthorus minutissimus)

Hosts. — Oaks of the red oak group.

Injury. — Transmission of a wilt disease through the feeding activities of a small bark beetle. The beetles feed at twig crotches, at the base of leaf petioles, and in rough places on the bark. They breed in the outer sapwood of small stems and branches of dying and recently dead trees and also in logging slash. The first indication of the disease is foliage wilting — appearing as pale and curled leaves which later turn bronze or brown. Limb and bole sprouts may develop, but usually the affected trees die the same year. Transmission of the disease may also occur through root grafts. Confirmation can be obtained by sending specimens of the insect and the injury to your State Entomologist.

Description. — The adults are small, slender, reddish-brown bark beetles, slightly more than one-sixteenth inch long. The larvae are white footless grubs; and, when full grown, about one-sixteenth inch long. The egg galleries are cut across the grain.

Phloem Necrosis

Elm Leafhopper
(Scaphoideus luteolus)

Hosts. — American elm and its horticultural varieties — moline and vase.

Injury. — Injection of a virus disease into the tree through the foliage. The nymphs feed on the lower surface of the leaves, sucking out the plant juices and at the same time introducing the virus. The first indication of phloem necrosis is foliage wilting similar to that caused by the Dutch elm disease. Confirmation can be obtained by sending insects or injury specimens to your State Entomologist.

Description. — The adults are tawny-red leafhoppers with traces of white at the thorax, and are about three-sixteenths inch long. The nymphs are dark brown, with a white dorsal band on the front part of the abdomen.

SPECIES NOT YET REPORTED

Several species, not yet known to be present in the Lake States, have caused damage in the Northeastern States. Some of these are imported species, others are native. The beech scale, (*Cryptococcus fagi*), for example, and its associated nectria bark disease, have caused widespread mortality of beech throughout northern New England and the Maritime Provinces of Canada. A list would include such insects as the birch leaf-mining sawfly (*Heterarthrus nemoratus*), elm casebearer (*Coleophora limosipennella*), imported willow leaf beetle (*Plagiodera versicolora*), maple leaf cutter (*Paraclemensia acerifoliella*), and maple petiole borer (*Caulocampus acericaulis*).

During surveys and other forest work it will be advisable to collect suspected specimens of insects and their damage and have them identified.

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Contains a key; a table giving clues to the identification of free-feeding defoliators; brief discussions of the hosts, tree damage, and description of many important hardwood insects; and 82 illustrations. The report is designed to help the fieldman without specialized training in entomology to identify insects causing tree damage. Some brief notes on life history and habits are included, but control methods are not discussed.

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